Interconnection Technical Standards Review Group (TSRG)
Duke Energy Carolinas/Progress
Meeting Agenda
January 21, 2020

9:00	Safety & housekeeping – Kevin Chen, Duke
9:10	Introductions & roster – Anthony Williams, Duke
9:15	September action items report – Anthony Williams, Duke
9:30	Review actions taken on FT and SR recommendations – Anthony Williams, Duke
10:30	Periodic self-inspection plan update – Kevin Chen, Duke
11:15	Inverter material modification issues concerning changeouts for adding storage to transmission solar plant – Bill Quaintance / Orvane Piper, Duke
12:00	LUNCH (provided by Duke)
1:00	System protection considering impact of DER (includes DTT) – Philip Baker, Duke
2:00	Inverter Volt-VAR study results – Guidehouse
3:00	Inverter Volt-VAR next steps – Guidehouse/Duke
4:00	1547 Order of Implementation and Plan Discussion – Anthony Williams, Duke
4:20	1547 Order of Implementation Stakeholder Discussion – Guidehouse/Duke
4:45	Wrap up & next meeting date – Wes Davis, Duke (Recommend April 21, 22)
5:00	ADJOURN

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January 21, 2020

I. Opening

This is a regular meeting called to order at 9:03 AM in Raleigh, NC

Meeting facilitator: Anthony Williams

Minutes: Raven Bowden

II. Record of Attendance

Member Attendance

Name	Affiliation	Attendance
Kevin Chen	Duke Energy	Present
Jeff Daugherty	Duke Energy	Absent
Wes Davis	Duke Energy	Present
Jonathan DeMay	Duke Energy	Phone
Raven Bowden	Duke Energy Contractor	Present
Huimin Li	Duke Energy	Absent
Orvane Piper	Duke Energy	Phone
Bill Quaintance	Duke Energy	Present
Jonathon Rhyne	Duke Energy	Absent
Jim Umbdenstock	Duke Energy	Absent
Anthony Williams	Duke Energy	Present
Stephen Barkaszi	Duke Energy	Phone
Paul Brucke	NCSEA, Sustainable Energy Assoc	Present
Jon Burke	GreenGo Energy	Absent
James Wolf	Yes Solar Solutions	Absent
Jason Epstein	Southern Current	Absent
Sean Grier	Duke Energy	Absent
Scott Griffith	Duke Energy	Present

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Name	Affiliation	Attendance
Chuck Ladd	Ecoplexus	Present
Bruce Magruder	Keytech Engineering	Absent
Luke ODea	Cypress Creek	Phone
Nwene Ogwu	Strata Solar	Absent
Chris Sandifer	SCSBA, Solar Business Alliance	Absent
Reigh Walling	NCCEBA, Clean Energy Bus Alli	Absent
Luke Rogers	Birdseye Renewable Energy	Absent
Dawn Hipp	SC Office of Regulatory Staff	Absent
Sarah Johnson	SC Office of Regulatory Staff	Absent
Robert Lawyer	SC Office of Regulatory Staff	Phone
Jay Lucas	NC Public Staff	Absent
James McLawhorn	NC Public Staff	Absent
Dustin Metz	NC Public Staff	Present
Tommy Williamson	NC Public Staff	Absent
Todd Rouse	Cypress Creek	Present
Max Semerau	Strata Solar	Absent
Mike Wallace	Ecoplexus	Absent
Moath Dardas	Strata Solar	Present
Harsha Chandavarapu	Guidehouse	Present
Radha Soorya	Guidehouse	Present
Rona Vo	SEL	Present

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Guest Attendance

Name	**Affiliation**	**Attendance**
Trent Miller	Duke Energy	Present
Brad Micallef	Solar Operations Solutions	Present
Staci Haggis	Advanced Energy	Present
Kelsy Green	Advanced Energy	Present
Gregory Ellena	Strata Solar	Present
Mike Whitson	PowerOnEnergy/Greengo	Present
Shawn Fitzpatrick	Advanced Energy	Present

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III. Current agenda items and discussion

1) The published agenda was emailed out.
2) September action items – Anthony Williams, Duke Energy
   A) Action Item Response: Duke will publish the requirements and clarify the transition period between the existing and revised requirements for sequential switching.
      i. Duke answer: Sequential switching changes are now in effect. The requirements for sequential switching were posted on the TSRG website.

   B) No discussion on Action Item; issue is closed.
3) PRESENTATION – Review actions taken on FT and SR recommendations – Anthony Williams, Duke Energy
   A) Presentation provided with minutes.
   B) Industry Question: Where can we find the EPRI and Duke reports to make comments?
      i. Duke answer: They are filed with the commission.
   C) Industry Question: Can you provide the EPRI Report and Duke Response?
      i. Duke answer: Yes, Duke can email the EPRI report and Duke response.
      ii. <u>ACTION ITEM – Email EPRI fast track and supplemental review report and Duke's response to the report to the TSRG.</u>
4) PRESENTATION – Periodic self-inspection plan update – Kevin Chen, Duke Energy
   A) Presentation provided with minutes
   B) Industry Question – Is the Q2, 2020 training to allow certification for self-inspection?
      i. Duke answer: No, that is for learning the process for self-inspection. What is being shown is simply a proposal. We don't intend to certify. Those who perform the inspection must have be a professional engineer and stamp the report.
   C) Industry Question: Is there a quantity for the amount of projects that will be subject to audit?
      i. Duke answer: That is to be determined, but we are inspecting 40-60 projects a year. This is subject to change, and Duke will work with Advanced Energy.
   D) Industry Question: What is the intention of the inspection? Are we looking for safety issues, or to keep the site in line with Duke standards?
      i. Duke answer: If you find a safety concern the intent is for you to correct that issue. It is not the intention to keep the site within Duke's standards. For instance, a site built 5 years ago should not be held to a standard created last year. The intent is not to bring your sites offline unless there is an issue concerning safety and power quality.

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ii. ACTION ITEM: Duke will create a rough draft of the self-inspection manual before the next TSRG meeting and provide for discussion at the meeting

5) PRESENTATION Inverter material modification issues concerning changeouts for adding storage to transmission solar plant Bill Quaintance, Duke Energy
   A) Presentation provided with minutes.
   B) Industry Question: When changing out inverters, for reasons such as age, should the inverters be like for like?
      i. Duke answer: New inverters must retain the same characteristics, such as total capacity or stability, as the original inverter. Otherwise, the change is considered a material modification.
6) PRESENTATION 1547 Order of Implementation and Plan Discussion Anthony Williams, Duke Energy
   A) Presentation Provided with Minutes
   B) No significant discussion during the presentation portion.
7) PRESENTATION 1547 Order of Implementation Stakeholder Discussion Duke Energy/Guidehouse
   A) Presentation Provided with Minutes
   B) Industry Question: Is Duke now saying 1547 applicable to the utilities?
      i. Duke answer: No, this is an inverter standard. The NC Commission asked Duke to evaluate the cost and benefit of implementation. However, the implementation of some functions have a direct impact on the Duke system. In those cases, Duke must make some decisions about how to apply this standard along with the Duke requirements. At the moment we do not know the frequency and voltage ride through settings.
   C) Industry Question: Once the studies are completed and goes through protection will there be Grid Services provided by Smart Inverter with storage in long run?
      i. Duke Answer: This effort is focusing on the impacts of implementing 1547, determining the applicable functions and settings, etc. Grid services are more related to markets and Balancing Authority needs, so that is out of scope for this discussion.
   D) Industry question: For Volt-Var Optimization have you considered smaller sample of voltage range than complete range?
      i. Duke Answer: Volt-Var Optimization study was conducted studies on the feeder head, middle and end and observed the response of smart inverter for real and power injections. The controllers were set so as not to interfere with the voltage optimization range.
   E) Several questions were posed at the end of the presentation with no significant discussion by attendees.
   F) Duke indicated preference to incorporating any Interoperability and Test requirements in with each of the individual 1547 sections. There were no objections.

8) PRESENTATION System Protection considering impact of DER (Includes DTT) Philip Baker Duke Energy
   A) Presentation Provided with Minutes
   B) Industry Question: Why is the SEL 2505 called out?
      i. Duke answer: That box is typical for Duke and has stronger communications security. Hardware has not been selected but this is the initial assumption due to simplicity, cost, reliability, security and it provides a fiber interface between Duke and the DER interface to address potential voltage differences between the communications interface equipment.
   C) Industry Question: How does this study relate to the current standards in DEC and DEP?
      i. Duke answer: As of right now there are no changes to requirements until the protection team and management agrees on the final standard. The areas of consensus and pending topics were reviewed.
   D) Industry Question: Is there any reason why there is a change of the communication medium from Utility to DER?
      i. Duke answer: To allow the DER developer to provide the medium they find most cost effective. The intent is to allow choices for the developer to provide their preferred medium or Duke can install fiber. Duke cannot technically support the range of variation and reliability or communications outages that will occur with 3rd party communications.
   E) Industry Question: Are you able to run fiber on overhead poles, as opposed to underground?
      i. Duke Answer: Duke Answer: If Duke installs fiber, it will likely be installed on poles. With developer owned mediums, the developer would weigh the cost and they would choose their preferred 3rd party method that likely uses existing infrastructure.
   F) Industry Question: Are there other solutions being looked into, besides DTT, to address islanding?
      i. Duke answer: Absolutely. We are currently looking into other solutions. Refer to the green text in slide 18 of the presentation for a sample of options being considered.
9) PRESENTATION Inverter Volt-VAR study results - Guidehouse
   A) Presentation Provided with Minutes
   B) Industry Question: Why were larger DER facilities not studied?
      i. Duke answer: This is a test circuit. We did not want to overload the circuit, and in some areas there are larger amounts of DER aggregated like the 2 MWs at the end of the feeder, while not as large as 5 MW they are close. In DEC, 2 MWs of DER is a common size. In the future we could consider larger sizes but the response is still easy to predict with the response curves.

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C) Industry Question: Were circuits with line voltage regulators looked into?
   i. Duke answer: At this point, these circuits were 24 kV and had no line voltage regulators. Duke will verify that some of the test feeders have LVR. At the moment, all these feeders were chosen at random.

D) Industry Question: Was controlled power factor looked in to as opposed to just Volt-VAR and Volt-Watt?
   i. Duke/Guidehouse answer: Not specifically, but Case 7 is effectively fixed power factor. Constant power factor is presently an available mode, but the focus of this study is on the new smart inverter functions as requested by the Commission.

E) Industry Question: Are you doing this to interconnect DER? What are you trying to get out the study?
   i. Duke Answer: This is to test the IEEE 1547-2018 standard and to understand the impacts to the system. As requested by TSRG members, yes, part of the reason for considering reactive power control first is to address the question about whether this will allow more interconnections. This study is intended to identify conditions under which VARS can be absorbed and meet transmission requirements. To maintain the T&D agreements we need to identify the mitigations to support the transmission network.

F) Industry Question: Are you developing the study scenarios to include the DEP system challenges?

Duke Answer: Developing scenarios that are applicable to each system. The study will be conducted on stressed cases to create the voltage condition. Then evaluating if a controller on one circuit works on others. Working around DSDR is a consideration too.

G) Industry Question: Industry Question: How many circuits are being studied?
   i. Duke Answer: We are evaluating 6 circuits now .

H) Industry Question: Generalizing the settings to all circuits might be a stretch, how many circuits are you studying?
   i. Duke Answer: Studying 6 different circuits, the studies will standardize the control setting range, if possible, which can integrate the smart inverters within the voltage limits of the circuit. If Duke determines that sample size is adequate to address the concerns, then there should be no need to expand. Duke will also take comments on how this may not be adequate.

I) Industry Question: Why is so much generation added?
   i. Duke answer: Yes, Duke could lessen penetration. The point of the study is to evaluate whether voltage and reactive power control could help interconnect more DER, as requested by the TSRG members. So, each case was stressed both for generation and also to have high voltage that the controls would need to mitigate. Without high voltage, there is nothing

for the study to evaluate. At low DER penetration there are not voltage issues, so there must be enough DER added to create the necessary voltage violation

j.

10) PRESENTATION Inverter Volt-VAR next steps Guidehouse/Duke Energy
   A) Presentation Provided with Minutes

11) Wrap up & next meeting date Wes Davis, Duke Energy
   A) Industry Question: Can the TSRG membership be changed to allow anyone to attend?
      i. Duke answer: The membership was set with the original charter. The intent was to have a mix of developers and some industry groups represented. The industry groups provide TSRG information to their members, but the TSRG information is also available to the public online. Over time, additional developers have requested to attend, and they have been added to the roster, although that was not strictly permitted by the charter.
      ii. ACTION ITEM: Duke to discuss membership at the next meeting.

IV. Next Meeting Date

The group tentatively selected April 28, 2020 for the next meeting.

V. Closing

The meeting adjourned at 3:50 PM

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VI. Attachments

1) Agenda, “TSRG Agenda 2019_0120, Rev 2.pdf”
2) Presentations:
   a. FT and SR Review, “FT SR Review Action Plan, Rev 4.pdf”
   b. Self-inspection plan, “Self-inspection plan_TSRG_01212020.pdf”
   c. Energy Storage Retrofit, “ESS Retrofit -Transmission Impact Review.pdf”
   d. IEEE 1547 Implementation, “Implement 1547, Jan2020, Rev0.pdf”
   e. IEEE 1547 Comment sheet, “TSRG_IEEE1547_Poll_CommentForm.xlsx”
   f. System Protection Considering Impact of DER (Includes DTT), “Interface Agreement, Protection, DTT - TSRG 2020 0121 Rev 2020 00120.pdf”
   g. Inverter Volt-VAR Study, “TSRG Volt-VAR Functionality Study.pdf”

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Action Items

Below are the action items from the TSRG meetings and their status.

Meeting	Item Number	Action Item	Summary	Status Summary
Apr-2018	1	Provide overall description of SIS process	Action Item description is too broad and requires scope clarification in order to take action	Hold
Apr-2018	2	Update TSRG on current and future work with Salesforce and PowerClerk	Agenda item for July 19	Complete
Apr-2018	3	Verify there is a feedback process to share owner issues and concerns about the process with Duke	An inspection and commissioning subcommittee was formed and part of the scope of this group is to address issues such as these. Therefore, the subcommittee will be the main forum for feedback. Update is agenda item for July 19.	Complete
Apr-2018	4	Identify various “operating requirements” and where best to document them	Action Item description is too broad and requires scope clarification in order to take action	Hold
Apr-2018	5	Provide status of effort to provide study reports to Requestors	This group within the company is being reorganized. The reporting is a known issue: when to communicate, what to communicate, how to communicate. There are efforts in the works to improve the situation, but it may worthwhile for TSRG members to recommend specific content.	Complete

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Meeting	Item Number	Action Item	Summary	Status Summary
Apr-2018	6	Provide typical DEP station and line regulator bandwidth settings	It is difficult to say that there are typical settings for voltage control devices like line regulators, station feeder regulators, station bus regulators, and station transformer tap changers. These devices are applied at different locations within the power system, which gives each type of device a different span of control. They also are configured to manage a variety of load densities and circuit lengths. Some applications use voltage drop compensation and those have a very different bandcenter setpoint than a unit that does not use compensation. A common bandwidth setting for DEC is 2V, but some zones have been designed with a 3 V bandwidth. With the DSDR requirements, most DEP bandwidths are 2V for line regulators and 1V for station regulators.	Complete
Apr-2018	7	Clarify how mitigating solutions are considered and applied	Action Item description is too broad and requires scope clarification in order to take action. This item is also addressed by item 14.	Complete

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Meeting	Item Number	Action Item	Summary	Status Summary
Apr-2018	8	DMS update on DER related functionality in ADMS	The current DMS deployment does not have integration of DERs into the advanced functions. In the future, this is a requirement for DSDR (optimized Peak reduction) in DEP. The DEP DMS is scheduled to be in service April 2019. Bear in mind that these project dates are movable based on changing priorities and constraints. As far as the following capabilities: • adjusting nominal voltage setpoint as a mitigation for negative voltage impacts, and • adjusting volt-var control to allow for alternative voltage control methods utilizing inverter capabilities Those capabilities are not included in the near term DMS implementations. These features add a great deal of complexity and are scheduled towards the end of the ADMS consolidation period and beyond. This schedule was based on balancing many priorities, constraints and commitments among many Duke Energy departments and functional groups. The adjustment of nominal voltage setpoint down as a mitigation for negative voltage impacts will be a part of the Modern Voltage Management Strategy, but that schedule is not in place yet.	Complete
Apr-2018	9	Provide information about the original need for RVC criteria	Provided 2 documents prior to the July meeting. One is a study from NC State University and one from Xcel Energy.	Complete
Apr-2018	10	Clarify inverter short circuit modeling methods	Studies use the short circuit capability from the submitted inverter specification sheet. Generally the Cyme Electronically Coupled Generator model is used with the specified fault contribution.	Complete
Apr-2018	11	Communicate information about material changes of transformer and inverter data	Provided document with march meeting minutes, "Dist-DER_Engr_and_Study_stds_clarifications-rev1-0.docx"	Complete

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Action Items

Meeting	Item Number	Action Item	Summary	Status Summary
Jul-2018	12	Post the information from July site inspections seminar	A Technical Training will be added to the webpage and contain the July training presentation and the Distribution Standards Reference Guide. Will post by 10/23/18.	Complete
Jul-2018	13	Process for smaller project feedback on the study process	All projects that are less than 20KW would need to inquire about the project's status through the Renewable Service Center. Their email address for inquiries is Customerownedgeneration@duke-energy.com. For projects greater than 20KW that are still within the study phase and haven't been released to an account manager, those projects can be directed to DERContracts@duke-energy.com. This is the email for OPSCAS team that handles project status inquiries before they are handed off to an account manager.	Complete
Jul-2018	14	Summarize the mitigation options along with the associated policies	Agenda item for October meeting	Complete
Jul-2018	15	Provide a summary of the Modern Voltage Management Strategy	This Strategy is not complete enough to share at this time. This can be reviewed with the TSRG at a future meeting.	Hold

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Action Items

Meeting	Item Number	Action Item	Summary	Status Summary
Jul-2018	16	Provide more details on operational limitations imposed by DSDR	A summary of the DSDR operational limitations will be provided during the October meeting.	Complete
Oct-2018	17	Method of selecting the study voltage for interconnection studies	Agenda item for Jan TSRG meeting	Complete
Oct-2018	18	Provide the level of solar above which DTT is considered	Agenda item for Jan TSRG meeting	Complete
Oct-2018	19	Status of Risk of Islanding Studies	Agenda item for Jan TSRG meeting	Complete
Jan-2019	20	Provide information from the EPRI DTT surveys	The EPRI report is not complete and will not be public. A total of approximately 50 utilities are represented in the survey. The load to generation ratio is a very common screening criterion. There is no consensus screening practice. Radio and fiber are the most commonly used for communication. A large portion of the utilities are currently reviewing DTT policies.	Complete
Jan-2019	21	Communicate bases for DTT on dedicated feeders to a distribution station	DTT is not required for distribution DER interconnections that have a dedicated feeder from the substation. If there was a need to isolate the generator, it would be tripped at the dedicated circuit breaker. A review of the interconnection requests showed a few interconnections that specified a dedicated feeder, but none with DTT required.	Complete

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Meeting	Item Number	Action Item	Summary	Status Summary
Jan-2019	22	Verify if 900 MHz radio is acceptable for DTT	There have been implementations of 900 MHz radio systems at various times on the Duke system. The Duke experience, and that of some co-ops, is these systems do not have high reliability and are susceptible to a variety of issues. Nevertheless, this communication option is considered as part of the enterprise-wide DTT policy review.	Complete
Jan-2019	23	Attempt to reconstruct the original basis for the 3% limit in the FCR	Duke noted at the last TSRG meeting the 3% limit has been in place at least a decade. We did not look any further back than that. Originally, the limit was 2% for transmission only and then was later increased to 3% and included distribution. The 3% is based on experience from actual events and considers that not every operating condition and customer sensitivity can be precisely anticipated and studied in advance.	Complete
Jan-2019	24	Provide more description on how the historical voltages are selected by the tools and software	Agenda item for May TSRG meeting	Complete
Jan-2019	25	Provide an overview of the distribution planning process	General scope like this is usually too broad to address effectively at TSRG. Duke prefers to focus on a specific issue that the industry prioritizes, like the voltage selection topic on the agenda for May.	Hold
May-2019	26	Duke will ask Protection if leased fiber is an option that is not currently communicated for distribution	Because of the poor reliability, troubleshooting and O&M issues, continued degradation of 3rd party equipment and service, along with the shorter distances between the station and the site, Duke does not allow the 3rd party fiber for distribution.	Complete
May-2019	27	Duke will provide a description of what is done for station-level DTT	The combined undervoltage and overvoltage (27/59) protection Duke installs is for the same purpose as 3V0. This protection was used prior to DER installations and one reason it was chosen was that it uses one less CVT than 3V0.	Complete

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Action Items

Meeting	Item Number	Action Item	Summary	Status Summary
Sept-2019	28	Duke will publish the requirements and clarify the transition period between the existing and revised requirements for sequential switching.	Agenda item for Jan TSRG meeting	Complete
January – 2020	29	Duke will create a rough draft of the self-inspection manual before the next TSRG meeting and provide for discussion at the meeting		Open
January-2020	30	Duke to discuss membership at the next meeting.		Open
January – 2020	31	Email EPRI fast track and supplemental review report and Duke's response to the report to the TSRG.		Open

Attachment D

Action Plan to Implement Recommendations from EPRI Review of Fast Track and Supplemental Review Process

Anthony C Williams, P.E.
Principal Engineer

DER Technical Standards

January 21, 2020

DUKE ENERGY

Overview

- This effort is intended to meet the following stipulation of the NC Public Staff in Docket No. E-100, Sub 101:

  Duke will consult with EPRI "regarding any potential modifications to the Fast Track and Supplemental Review process. DEC and DEP will commence such process no later than April 1, 2019 and will provide a summary report regarding any potential modifications at the Technical Standards Review Group meeting occurring in the third quarter of 2019." To address this stipulation EPRI will provide evaluation of Duke Energy's interconnection.
- The review is complete, report submitted to Commission, Duke & public responses filed
- EPRI generally found
  - implementation and execution of the Section 3.2 Fast Track process sufficient
  - overall assessment that Supplemental Review criteria has appropriate transparency and clarity.

Recommendation: *Periodically review Fast Track eligibility relative to the size range and the number of applications submitted and consider if adjusting the limits is warranted.*

- The Companies plan to monitor interconnection applications eligible for Fast Track over the next 12-24 months and consider whether the number of applications of smaller DER above current Fast Track eligibility limits increases, and if so,
- whether potential changes would help facilitate more efficient processing of increased numbers of Interconnection Requests while also protecting system safety and reliability.

Actions

To begin within 30 days following TSRG

- Duke will track the interconnection requests submitted over the next 12-24 months and their results to determine if there are any indicators that could be used as an eligibility for Fast Track, or if the existing eligibility limits need revision. Such items that will be tracked include, but are not limited to:
  - Project size
  - Resulting upgrades
  - Whether applicable projects required an inrush study and the results
  - Distance from the substation
  - Installed and queued ahead generation impacting interconnection request
  - Stiffness ratios

<u>Recommendation:</u> *Inform developers, during the TSRG and like meetings, about the option to pre-approve Supplemental Review for larger projects eligible for Fast Track. Publish the technical criteria used in Supplemental Review.*

- The Companies currently explain the pre-approval option to Interconnection Customers on an as-needed basis.
- The Companies also recently published the technical criteria that Duke applies in the Supplemental Review process where Fast Track and Supplemental Review are discussed.

Actions to begin within 30 days following TSRG

- Duke already has a notice on the interconnection website
  - https://www.duke-energy.com/business/products/renewables/generate-your-own/interconnection-more-than-20kw
- Duke is also considering changes to the online application form on the customer portal.

Recommendation: *Duke should clarify how line sections are defined in screen 3.2.1.2 in its Method of Service and/or TIR document. EPRI recommends using the actual minimum load rather than the 15% proxy.*

- MOSG and NCIP changes.
- The Companies accept and agree to clarify how line sections are defined. Part of that is excluding the service transformer section. The Method of Service Guidelines will be updated with a diagram or diagrams similar to the next two slides
- When there are multiple Interconnection Customers on a single transformer, EPRI recognizes that the Companies must still study whether DER operational or setting changes are required to ensure reliability and power quality are maintained
- The Companies also agree to use the actual minimum load rather than the 15% proxy load, when the actual minimum load on the related section is readily available.

3.5 Line Section Identification

As part of the interconnection process, the term "line section" is used for some NCIP screens. The common boundaries of a line section are an automatic sectionalizing device or the end of the line. However, within that, there can be many types and variations of line sections. The following diagram, Figure 1, illustrates some of that variety.

Line Section	Description
LS1	Feeder Breaker Section
LS2	Recloser Section
LS3	Breaker First Section
LS4	Recloser First Section
LS5	Lateral First Section
LS6	Main Fused Section
LS7	Service Transformer Section
LS8	Lateral Entire Section

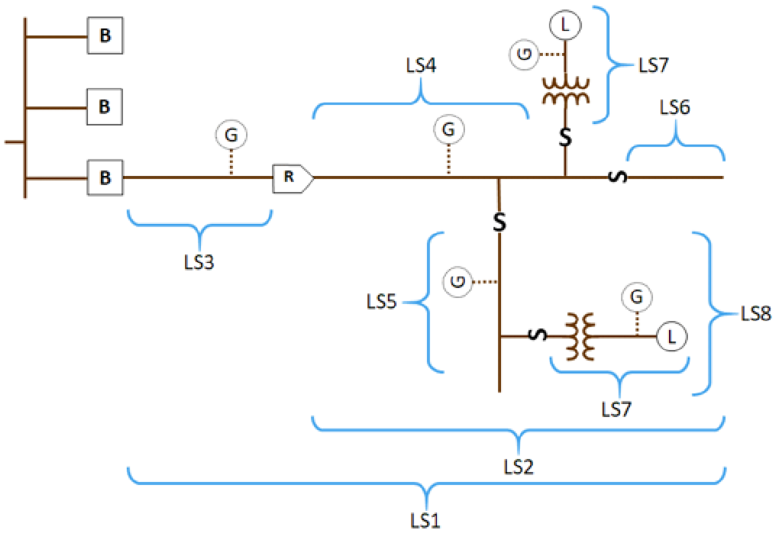

Figure 1

MOSG 3.5 Changes for NCIP 3.2.1.2

While the service transformer line section is a concern for the screening criteria, it is expected that only a single customer, rated >20 kW to < 1,000 kW, to interconnect to a service transformer. Under those conditions, just specified, Duke will exclude the service transformer section from the screen.

By omitting the service transformer automatic sectionalizing device, the second upstream automatic sectionalizing device will be used for the screen. For the example feeder above, the distributed generation connected to the service transformer will be compared to the recloser and lateral fuse as shown in Figure 2.

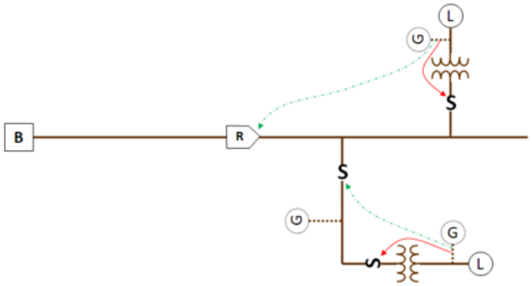

Figure 2

In the uncommon situation that there are multiple Interconnection Customers of this size on a single transformer, Duke must still study whether DER operational or setting changes are required to ensure reliability and power quality are maintained. Some of the reliability or power quality risk created by not including the service transformer line section is also mitigated by the 3.2.1.8 screen for transformer loading. Higher loading on transformers in this rating range should help identify situations of reliability and power quality concerns.

Actions

To finalize plan within 60 days following TSRG

- Multiple DER on a single service transformer – However, when such an event occurs, the aggregate generation will be evaluated on the <u>secondary</u> side of the service transformer using an allocated circuit analysis model. Actual, if available, or typical secondary conductors will be included within the modeling in an effort to evaluate any adverse impacts that may occur. Such impacts may be excessive voltage rise along the secondary conductors, low voltage side RVC violations, etc.
- Actual minimum load – For interconnection requests whose line section begins with a SCADA enabled device, actual historical data will be utilized to determine minimum load. For line sections that do not begin with SCADA enabled devices (i.e. fuses, hydraulic reclosers), an attempt will be made to allocate minimum load on that line section in power flow. In some instances, the feeder or line section will not solve correctly under these low load conditions. In those situations, by necessity, load must be estimated or calculated for the line section when there is no measurement.

Proposed Changes for NCIP 3.2.1.2

To finalize plan within 60 days following TSRG

- Current NCIP 3.2.1.2:

  For interconnection of a proposed Generating Facility to a radial distribution circuit, the aggregated generation, including the proposed Generating Facility, on the circuit shall not exceed 15% of the line section annual peak load as most recently measured at the substation. A line section is that portion of a Utility's System connected to a customer bounded by automatic sectionalizing devices or the end of the distribution line.

- Duke proposed revision to the screen:

  For interconnection of a proposed Generating Facility to a radial distribution circuit, the aggregated generation, including the proposed Generating Facility, on the line section shall not exceed 15% of the line section's most recent annual peak load or, alternatively, the most recent actual annual minimum load. The load should be based on measurement, if available, and load can be estimated or calculated for the line section when there is no measurement. A line section is that portion of a Utility's System, connected to a proposed Generating Facility, bounded by automatic sectionalizing devices or the end of the distribution line.

Recommendation: *Update inverter grounding requirements in both Duke's public technical requirements and in the NCIP changes to Screen 3.2.1.7.*

- MOSG and NCIP changes.
- Duke agrees that the language of Section 3.2.1.7 should better align with actual practice for inverter-connected DER.

MOSG 3.6 Changes for NCIP 3.2.17

3.6 DER Interconnection Ground Source

DER facilities that provide a ground source to the power system at the point of interconnection require a grounding study. The purpose of this evaluation is to consider effectiveness in limiting ground fault over-voltage and if any changes are required for protection settings. Considerations for this study include the line configuration, the transformer connection, the type of DER, the nature of the load, and the design of any supplemental ground source, if used. Each DER interconnection design shall be evaluated and accepted based on compatibility and coordination with the utility system as a requirement of IEEE 1547.

The study scope will include the minimum of:

a. Facilities not approved via fast track review shall have a grounding study to determine the design to achieve DER source grounding to provide adequate primary-side zero-sequence impedance.
b. Grounding study for rotating generators DER shall demonstrate that the DER system is effectively grounded as per IEEE C62.92.1 ($X0/X1<3$) and ($R0/X1<1$), IEEE C62.92.2, and IEEE C62.92.3.
c. Grounding study for inverter-based DER, grounding requirements depend on the utility system and DER design conditions, but generally must meet a coefficient of grounding less than 0.8, as defined by IEEE C62.92.1 and IEEE C62.92.6, is maintained on any section of the distribution system that can potentially be energized by the DER.
d. Consideration of any supplemental grounding design included in the DER interconnection.

Proposed Changes for NCIP 3.2.1.7

To finalize plan within 60 days following TSRG

- Current NCIP 3.2.1.7:

  Using the table below, determine the type of interconnection to a primary distribution line. This screen includes a review of the type of electrical service to be provided to the Interconnection Customer, including line configuration and the transformer connection for the purpose of limiting the potential for creating over-voltages on the Utility's System due to a loss of ground during the operating time of any anti-islanding function.

Primary Distribution Line Type	Type of Interconnection to Primary Distribution Line	Result/Criteria
Three-phase, three wire	3-phase or single phase, phase-to-phase	Pass Screen
Three-phase, four wire	Effectively-grounded three-phase or single phase, line-to-	Pass Screen

- Duke proposed revision to the screen – still working with EPRI:

  Three-phase Grid-following inverter DER shall be connected as required by IEEE 1547. If supplemental grounding is provided, the DER interconnection fails screen. Grid-forming inverters and rotating DER fail the screen.

- Still working on single phase and a table
- Still discussing with EPRI: turning out to be harder to get a 'screen' than originally anticipated.

Recommendation: *Supplemental Review criteria for power quality may be more effective if a stiffness ratio calculation at the PCC is included with the limits currently used.*

- The Companies have effectively replaced the circuit stiffness ratio estimate with actual calculations for harmonics and voltage change.
- Duke will review the current process and consider applications for the stiffness ratio as a preliminary power quality assessment tool during Supplemental Review.
  - Duke will present any proposed uses at the TSRG in the January 2020 meeting and proceed with any changes based on stakeholder feedback.
- Actions
  - One reason Duke moved away from using the Stiffness Ratio to performing an individual study was that Duke often disputes over using the Stiffness Ratio. It is difficult for a single ratio to apply across a broad variety of feeders and DER.
  - Duke will continue to investigate any correlations between higher stiffness factor scores and portions of the SIS that pass consistently to determine if a factor is as useful as the calculation

Recommendation: *Document the existing FT screen and the SR processes and any possible exceptions relative to fault clearing practices described in the Report.*

- SR and NCIP changes.
- EPRI accepts, the Companies' practice; however, this exact practice is not specified in the NCIPs. Duke will propose a change to NCIP and clarify the Supplemental Review description.

Proposed Changes for NCIP 3.2.1.6

To finalize plan within 60 days following TSRG

- Current NCIP 3.2.1.6:

  The proposed Generating Facility, in aggregate with other generation on the distribution circuit, shall not cause any distribution protective devices and equipment (including, but not limited to, substation breakers, fuse cutouts, and line reclosers), or Interconnection Customer equipment on the system to exceed 87.5% of the short circuit interrupting capability; nor shall the interconnection be approved for a circuit that already exceeds 87.5% of the short circuit interrupting capability.

- Duke proposed revision to the NCIP Fast Track screen that agrees with current practice:
  The fault current level, without the addition of the Generating Facility, at any distribution protective devices and equipment (including, but not limited to, substation breakers, fuse cutouts, and line reclosers) or Interconnection Customer equipment on the proposed Generating Facility circuit shall not exceed 87.5% of the short circuit interrupting capability.

- Duke proposed revision to the Supplemental Review description that agrees with current practice:
  The proposed Generating Facility, in aggregate with other generation on the distribution circuit, shall not cause any distribution protective devices and equipment (including, but not limited to, substation breakers, fuse cutouts, and line reclosers), or Interconnection Customer equipment on the circuit to exceed 95% of the short circuit interrupting capability. Upgrades will be considered above 95% of the capability.

Conclusion

- Discussion on action items
- Duke will proceed with action items as stated

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Attachment E

Periodic Inspection Program
Self-inspection Plan

Kevin Chen 1/21/2020

DUKE ENERGY

Agenda

- Periodic Inspection Pilot Overview
- Self-inspection Plan
- Proposal of timeline moving forward
- Q&A, open discussion

Recap AE’s presentation in last TSRG meeting

Periodic Inspection Pilot Overview

For Existing Distribution Connected Utility Scale Solar in Carolinas (>=1MW)

- Approx. 300 sites connected to Duke Energy distribution system prior to **mid-2016** with limited or no commissioning conducted by Duke Energy. Duke decided to run this pilot to determine the scope and process for a periodic inspection program.
- Pilot sites ranged in capacity from 2-5 MW and entered service 2012-2015, and were inspected from the AC side of the inverters to the point of interconnection (POI).
- The scope includes: expected vs. installed equipment; interconnection construction – safety & reliability issues; inverter settings; commissioning test (cease-to-energize & restart delay, IEEE 1547.1-2005 Clause 7.5).
- Pilot inspection in 2018: 4 sites (3 in DEP, 1 in DEC), 1 of them was tested.
- Pilot inspection in 2019: 5 sites (4 in DEP, 1 in DEC), all of them were tested.
- Inspection report has been delivered to each customer.

- AE presented the findings overview at the 9/17/2019 TSRG meeting. And some comments were received.

Expected vs. Installed Equipment

- ☑ 5 sites
- ☒ 4 sites

Inverter Settings

- ☑ 1 site
- ☒ 8 sites
  - Grid protection: 8
  - Reconnect timer: 3
  - Maximum export: 3
  - Power factor: 1

Interconnection Construction

- ☒ All sites had conditions requiring immediate correction
- ☒ All sites had conditions requiring supervision

Commissioning Tests

- ☑ 4 sites passed
- ☒ 2 sites restarted prematurely after grid restoration

*3 sites in 2018 did not have a commissioning test performed

advanced energy

Self-inspection Plan

For Existing Distribution Connected Utility Scale Solar in Carolinas (>=1MW)

- Summary

  Define a self-inspection plan for all existing in-service utility scale PV in DEC and DEP, which can be economically implemented by the interconnection customers and can help Duke Energy maintain a database of DER compliance to applicable standards and codes.

- Objectives

  1. Continuously improve the quality, safety, reliability and contractual compliance of utility-scale PV interconnections in North Carolina and South Carolina.
  2. Continuously ensure the operational compliance of utility scale DER according to IEEE 1547.
  3. Encourage DER customers to maintain and operate DER system safely and reliably.
  4. Provide DER customers with flexibilities in choosing inspection service providers.
  5. Manage high volume of DER customers in an effective and efficient way.

- A sufficient self-inspection together with inspection report shall cover the following subjects:
  1. Compare and verify the installed system matches the approved/filed documents at Duke.
     - Most recent SLD that reflects the DER facility as built shall be submitted to Duke.
  2. Inverter setting verification and logging.
     - The latest (correct) settings shall be logged and send to Duke for record.
  3. Point of Interconnection access maintenance.
     - Turn in photos to prove the access to Duke's facility is clear.
  4. Check for the immediate safety, reliability issues in a utility scale DER. (minimum requirement)
     - Need proof of correction together with the self-inspection report.
  5. Check for issues that may be prone to deterioration or present a reliability risk.
     - These shall be monitored on an ongoing basis, and corrected through O&M cycles.
  6. Recommend good practice and longevity related items. (Optional)

- **Self-inspection Instruction Manual** – A comprehensive document to help the interconnection customers understand the requirements of the self-inspection. It shall include examples with notes, diagrams and pictures together, and a sample report to set expectations.
- **Self-inspection Notification Package** – The package includes: self-inspection process document, self-inspection instruction manual, Duke approved SLD on file, tables of Duke approved equipment and expected inverter settings, etc.
- **Full-scale Audit Inspection** – The scope of this inspection is similar to the periodic inspection pilot in 2019. The scope of this inspection includes: (1) expected vs. installed equipment; (2) interconnection construction – safety & reliability issues; (3) inverter settings; (4) commissioning test.

1. The customers being selected for self-inspection will be notified by Duke Energy representative. Along with the notice, a self-inspection notification package shall be provided to each customer. Notices could be delivered to customers on a quarterly or semi-annual schedule to spread the report submissions throughout the year.

2. The self-inspection is at customer's cost and a customer can choose any qualified resource on the market to perform the self-inspection following the instruction. The customer is required to submit the self-inspection report (PE stamped) back within 120 days of the notice.

3. The self-inspection report shall include acknowledgment that "*All identified deficiencies in the report have been addressed. If any action from Duke Energy is deemed necessary due to any issues not identified in the report or not fully addressed, it will be at customer's cost.*"

4. AE will help Duke collect the self-inspection report and perform engineering review on it.
    a. Low quality self-inspection report will be considered as "insufficient inspection". And the DER project will be assigned with a high risk score.
    b. Not being able to provide self-inspection report will result in “automatic non-compliance”. The non-compliant project will be subject to Full-scale Audit Inspection at customer’s cost.
5. Periodic inspection is required as continuous compliance needs to be verified. Different components in a DER project will require different inspection cycles.
    a. Construction quality and site maintenance self-inspection with report is required every 5 years for the DER project with all previously identified construction quality issues addressed and without new construction (5-year cycle).
    b. The inverter setting compliance self-checking shall be performed annually (1-year cycle), and the inverter setting report shall be submitted to Duke for record.
    c. The picture of the Duke’s POI access road shall be submitted annually together with the inverter setting report (1-year cycle).

6. Duke and AE will maintain a database of compliance risk of all DER projects. The projects with high risk score will be selected for self-inspection first. The following criteria will be considered to determine the compliance risk score of a DER project:

   a. Quality of the self-inspection report

   b. DCC DG event notification, or any DER operational issue reported to Duke Energy

   c. Major site reconstruction or inverter replacement due to system upgrade, equipment wear and tear, or natural disasters (hurricane, earthquake, tornado, storm, etc.)

   d. Number of years in service since last successful inspection and cease-to-energize test

   e. Potential impact to critical/sensitive retail load customers

   f. Revenue meter data screening results

   g. Random selection (only used as tie-breaker)

7. Duke and AE will help DER interconnection customers meet all requirements through self-inspection. However, the Full-scale Audit Inspection will be required at the customer's cost if any of following conditions is met.
   a. The DER project is deemed as non-compliance by not responding to the self-inspection notice after reminders.
   b. The DER project had insufficient self-inspection and the customer failed to address the conditions requiring immediate correction.
   c. The DER interconnection customer cannot find other resource to perform the self-inspection, and request Duke and AE to inspect the project.

Proposal of Timeline Moving Forward

- 1/21/2020 – Present the initial version of self-inspection plan at TSRG meeting
- Q1 and Q2, 2020 – Collect feedback and refine the self-inspection process document
- Q1, 2020 – Complete the Self-inspection Instruction Manual (under development now)
- Q2, 2020 – Organize training on the topic of self-inspection
- Q3, 2020 – Pilot the program
- Q4, 2020 – Reserved for regular DER end-of-year commissioning
- Full deployment of self-inspection program may be in 2021.

Q&A, Open Discussion

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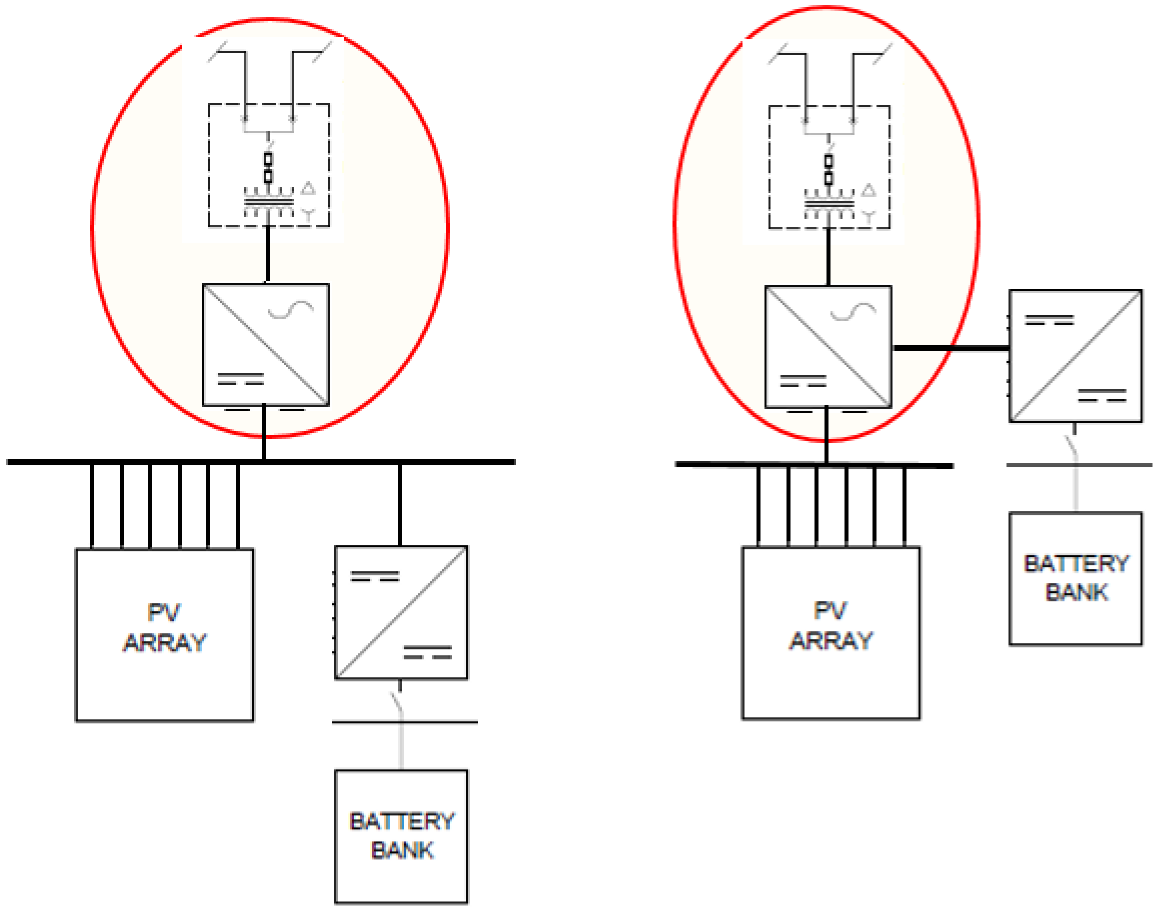
ESS Retrofit -Transmission Impact Review

Documentation Review:
- Solar
- Existing Site or have an executed IA
- DC-Coupled Configuration
- Must retain inverters that were originally studied.
- No change to Max AC Capability

Grouping Study:
- Winter peak power flow
- Base case includes all queue requests with completed SIS
- Stakeholder Meeting



Attachment F

BUILDING A **SMARTER** ENERGY FUTURE℠

TSRG Meeting 01/21/20
Transmission – Distribution Interface Agreement – DER Enterprise Standards Project – Update

Agenda

- Scope
- Team Organization
- Overview
- Universal Requirements
- Initial Screens
- Higher-Level Study and Requirements
- Consensus Reached Summary (Project Team)
- Ongoing Work
- Summary – IBR Only (Selected Items)
- Project Status

Scope

Title: Transmission – Distribution Interface Agreement – DER (Distribution Connected)

- Enterprise consensus standard (NC, SC, Florida, Indiana, Ohio, Kentucky)
- Transmission and Customer Delivery (Distribution)
- System Protection (Utility System) considering DERs as a source
  - De-energizing Faulted Protection Zones and Unintentional Islands
  - Protecting utility company assets
  - Power Quality
  - Safety
  - Protection Settings for Ride-Through of Transmission level events
- Establish Boundaries & Responsibilities
- Screening Criteria for System Protection
- System Protection Solutions and Requirements

Attachment G

Scope

T-D Substation

Transmission

Transformer

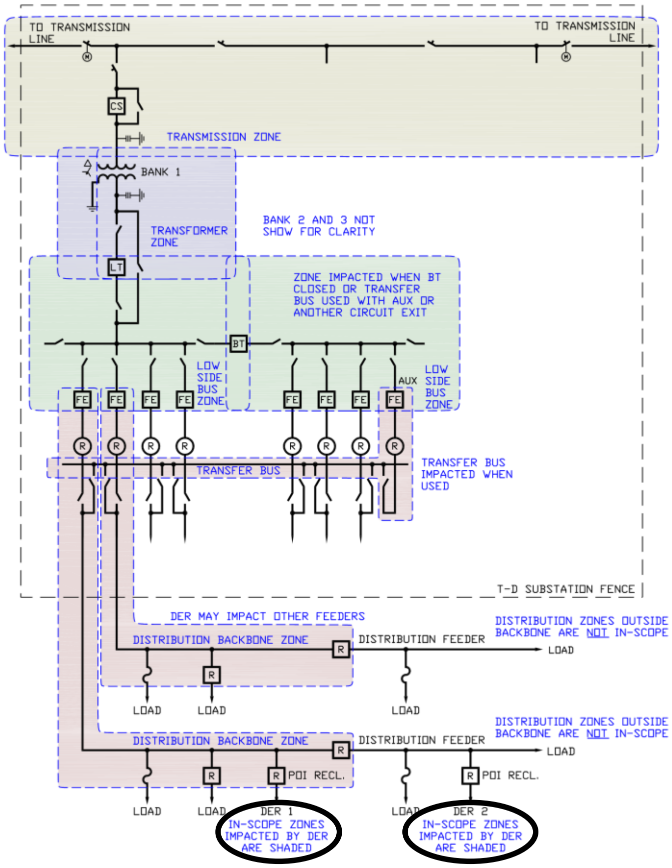
Low Side Bus

Transfer Bus

Distribution Feeders

DER

Both Sites are In-Scope



Multiple System Protection zones are impacted by DER.

Team Organization

Attachment G

Transmission (Project Team)

- Transmission Standards – EW
- NERC Reliability & Security – EW
- Transmission Prot. & Control (Regions) (DEC, DEP, DEF, DEMW)
- Operational Standards (Distribution) – EW

Customer Delivery (Distribution)

- Operational Standards (Distribution) – EW
- Reliability Engr. Carolinas DG Group
- Distribution Planning – EW
- Transmission Standards – EW

EW = Enterprise Wide

Extended Team

- Management (T & CD)
- Trans. & Dist. DER Tech Std.
- Reliability Eng. DPAC
- Telecom
- Grid Mon. & Crtl. Intel.
- NERC Reliability & Security – EW
- Performance Support
- Work Methods (T & D)
- Associate Gen. Counsel
- Std. PPAs & Interconnects
- System Ops & Planning (T)

Overview

General Approach:

- Use initial Screening Criteria and, when those criteria are breached, progress to Higher-Level Study and Requirements.
- After all preferable options are exhausted, Direct Transfer Trip (DTT) will be required.
- Retain the standards development project team as a standing team.

Note: New requirements or significant changes are required in all operating areas.

Universal Requirements

- POI Recloser Required:
  - IBR > = 1 MW
  - All Rotating Machines
- POI Recloser Local Protection Settings:
  - Standard settings that balance protection and Ride-Through
  - ROCOF turned ON
- DER Local Protection Settings (On-Board):
  - Passive Protection Settings set a margin higher than POI Recloser
  - ROCOF turned OFF
  - On-board Active AI schemes turned ON. Note: Industry standards are evolving, 1547.1 202?

Universal Requirements

- Self-Optimizing Grid: Trip DER for event, Block close when in abnormal configuration
- Trip Feeder exit breakers for substation events, (Faults or De-energization)
  - Standard new station design. Also apply if initial screens fail.
- Standard feeder exit reclose timer = 2 Seconds
- Maximum Run-on-Time (ROT) = 2 Seconds
- Daylight hours between 7:00am – 8:00pm used in PV screens
- Trans. L-G fault protection if DER on Sub. transformer => 67% Min Gross Load
- Trans. 3LG & L-L faults, *Dependent on POI Recl. Setting research*
- Feeder exit line side VT: Rotating DER or when reclose < 2 seconds

  (Refer to Satellite Synchronized Clocks in Higher-Level Study and Requirements)

Initial Screens

All IBR DER

- DER aggregate (AC) active power rating => 2/3 of the minimum Gross Load

  Note: *Ratio is dependent on POI Recloser Settings*

All Rotating DER

- DER aggregate (AC) active power rating => 1/3 of the minimum Gross Load

IBR & Rotating Mixed

- Site specific study

Higher-Level Study and Requirements

Satellite Synchronized Clocks: (Enables event analysis without feeder exit Line-side VTs)

- Install at Feeder Exits and POI Reclosers if initial screens fail

Feeder Exit Live Line Reclose Supervision:

- Rotating DER or special cases where reclose times are less than 2 seconds

Induced Passive Trip caused by de-energization of another DER site

- Trip at a Large site with DTT may induce trip at another site using passive elements

Rotating Machines: Site specific study

Higher-Level Study and Requirements

Direct Transfer Trip (DTT) from Feeder Exit to DER

- Install when initial screens and Higher-Level Study fails
- Trip for Loss of Communication

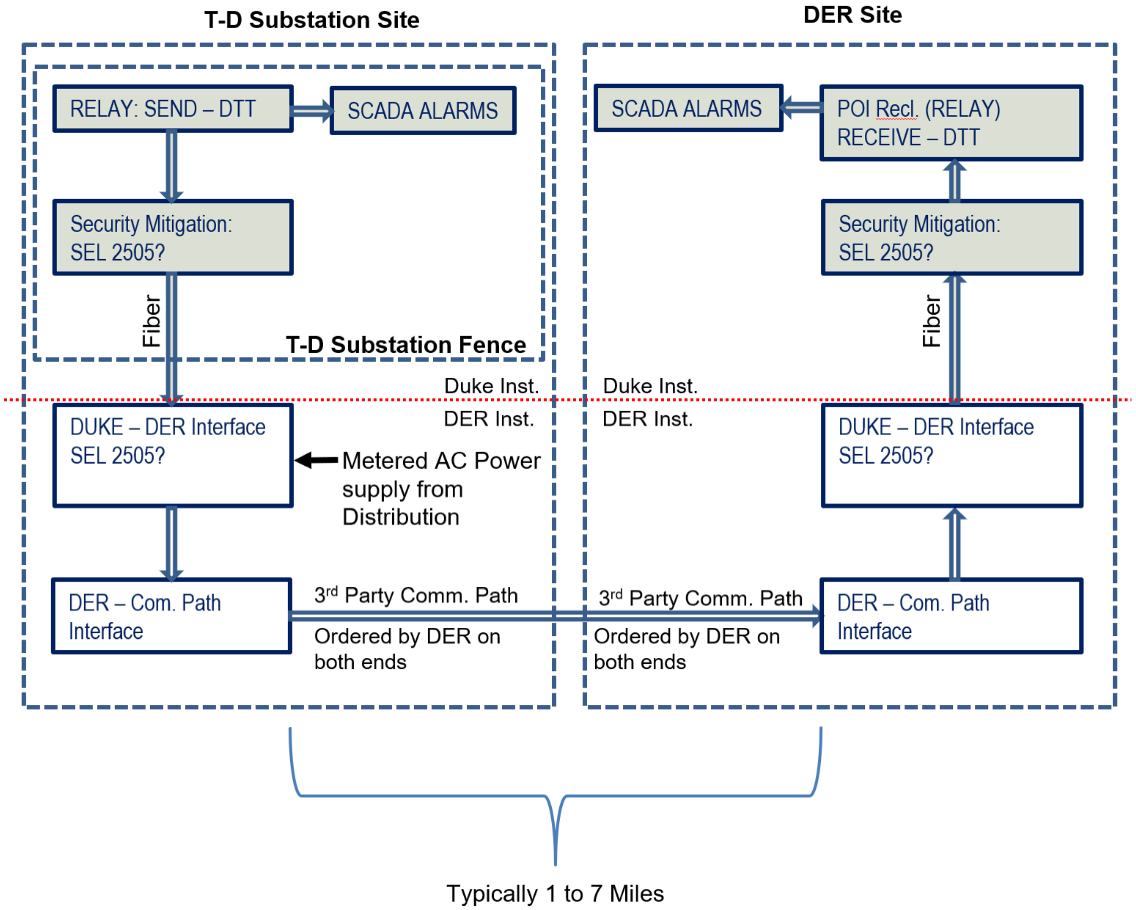
DTT Medium Options Feeder Exit to DER

- Duke-Owned and Maintained Mediums: Fiber (ADSS)
- DER Owned and Maintained Mediums: Refer to the next slide

- Note: Radio Frequency Options:
  - Up-front cost likely equal or exceed the cost of fiber
  - Not pursuing as a standard option

Higher-Level Study and Requirements

DER Owned and Maintained Mediums:



Legend

Communication Paths indicated.
Power Interface not shown.

Installed by Duke

Installed by DER

Consensus Reached Summary (Project Team)

- Fundamental Protection Requirements
  - Minimum Design Criteria
  - Goals
  - Considerations
- Evaluation Criteria for Protection screens and solutions
- Transmission & Customer Delivery boundaries responsibilities for maintenance
- Primary T & D protection responsibilities Note: *Dependent on POI Recloser Settings*
- POI Recloser Requirement
- Policy as it relates to load customers with long term parallel generation
- Transmission Voltage based L-G fault scheme guidance
- Self Optimizing Grid, DER Response – current practice is acceptable

Consensus Reached Summary (Project Team)

- **Maximum Run-On-Time (ROT)**
- **Load ratio screens –** *Note: Ratio dependent on POI recloser settings*
- **Daylight hours for PV Gen / Load ratios**
- **Large DER with DTT induces trip at smaller DER**
- **Trip feeder exit breakers for substation faults or connection to grid open**
- **DTT Feeder Exit to DER Required after all screens and other solutions fail**
- **DTT scheme guidance for sending end (substation schemes)**
- **DTT Com. Medium (Duke = Fiber or DER provides path)**
- **DTT Loss of Communication**
- **Reclose coordination**

Ongoing Work

Attachment G

- POI Recloser Settings:
  - MATLAB Modeling iterations. Balance protection performance and Ride-Through
- Dependencies on POI Recloser Settings:
  - Transmission Ride-Through
  - Under Freq. Load Shed and Under Voltage Load Shed coordination
  - Transmission 3LG & L-L faults
  - Initial Screen Gen-to-Load ratios
  - Primary T & D protection responsibilities
  - DER Passive Settings

Ongoing Work

- Flowchart
- Industry Research, IEEE, SANDIA / EPRI
- Rotating Machines: Initial Screens & Higher-Level study, Site specific study
- IBR & Rotating Mixed: Initial Screens & Higher-Level study, Site specific study
- Risk-Based Studies: Protection for island NDZ
  - Risk of Islanding (ROI) Studies with external consultant
  - Risk of Islanding (ROI) Studies with internal resources (Preference)
  - Quantifiable acceptable risk level in NDZ Hours / year. (Difficult task)

Ongoing Work

NDZ Active Prevention Scheme: **

- Scheme either actively prevents or limits the time a NDZ may exist.
- Monitor real and/or reactive power flow at a protection device that, if opened during a NDZ, may initiate an unintentional island.
- Communicate Power flow data to the DER site. SCADA communication mediums may be used as protection speeds are not required.
- Logic at the DER site requests the DER to modify output to stay out of NDZ condition.
- If the communication medium fails, the DER site may continue operation at predetermined output levels that have been determined to avoid a NDZ on a seasonal or annual basis.

** Conceptual idea.

Summary – IBR Only (Selected Items)

Initial Screens

- Ratio Screens

  Universal Requirements

  - POI Recloser with new standard settings (Settings – Ongoing Work)
  - Trip Feeder Exit Breakers for substation Events (After Initial Screens)
  - Transmission L-G Fault protection (Ratio Based)
  - Transmission 3-Phase and Line – Line Fault Protection (Ongoing Work)

    Higher Level

    - Satellite Synchronized Clocks (After Initial Screens)
    - Local protection performance evaluation (Ongoing Work)
    - Risk based studies (preference for internal resources (Ongoing Work)
    - Induced Passive Trip
    - NDZ Active Prevention Scheme (Conceptual idea)
    - DTT Feeder Exit to DER (Offer communication medium options)

Project Status

Attachment G

Early Draft sent to Extended Team for Review. Comments due 1/24/20.

Complete Ongoing Work, (Mainly POI Recl Setting research and Risk Based Policy)

Resolve Comments and edits.

Publish (Internally mid 2020)

- **Researching methods to publish content externally.**

Change Management (Schedule determined by impacted groups & dependent on changes required.)

Attachment G

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Attachment H

Duke Energy inverter Volt-Var Functionality Study

Stakeholder Meeting

Date:01/21/2020

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Agenda

- Ground Rules
- Guiding Principles
- Logistics
- Timeline
- Overview of Volt-Var Functionality Study
- Preliminary Results of Volt-Var Study
  - DEC system
  - DEP system
  - Summary of Results
- Next Steps

Ground Rules

- All Stakeholder Group meetings, webinars and information exchange are designed solely to provide an open forum or means for the expression of various points of view in compliance with **antitrust laws**.
- Under no circumstances shall Stakeholder Group activities be used as a means for competing companies to reach any understanding, expressed or implied, which tends to restrict competition, or in any way, to impair the ability of participating members to exercise independent business judgment regarding matters affecting competition or regulatory positions.
- Proprietary information shall not be disclosed by any participant during any group meetings. In addition, no information of a secret or **proprietary** nature shall be made available to Stakeholder Group members.
- All proprietary information which may nonetheless be publicly disclosed by any participant during any group meeting shall be deemed to have been disclosed on a non-confidential basis, without any restrictions on use by anyone, except that no valid copyright or patent right shall be deemed to have been waived by such disclosure.

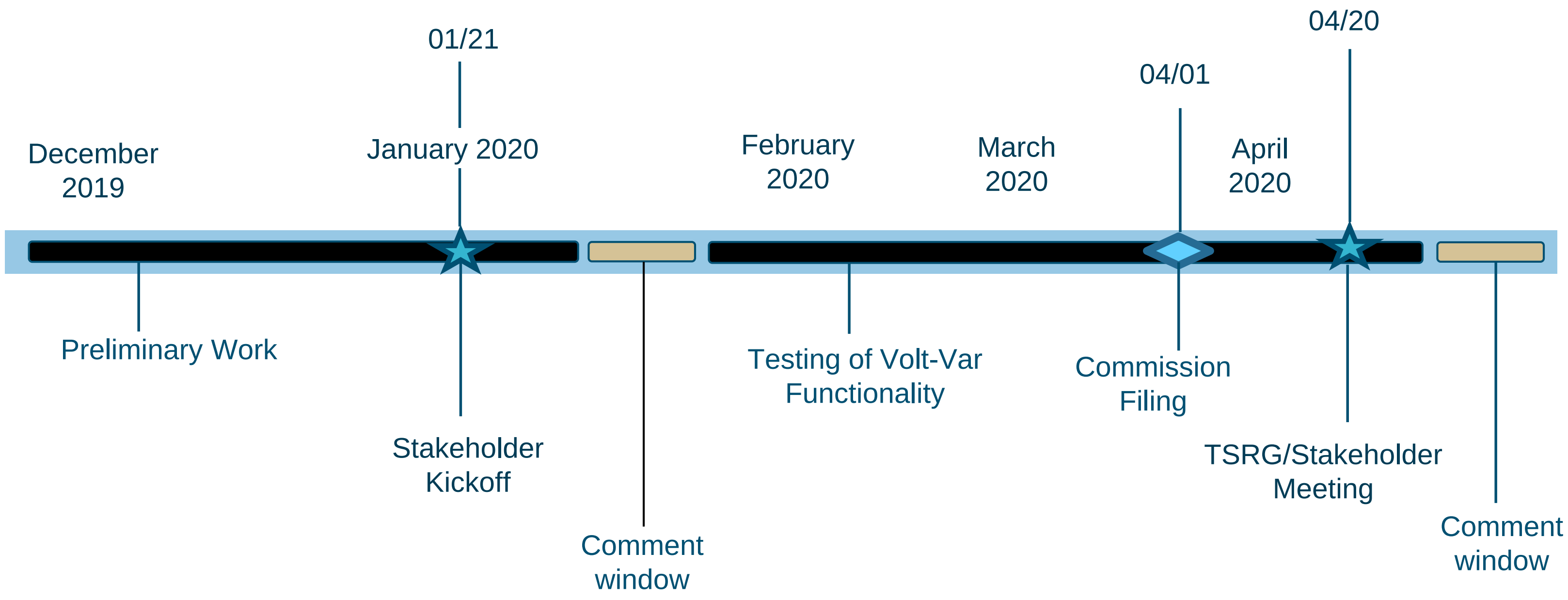
Guiding Principles

- North Carolina Commission had tasked Duke to evaluate software-based controls of advanced inverters according to IEEE 1547-2018 standard.
- Evaluate the use of autonomous voltage-reactive power control functions at multiple inverter-based distributed energy resources connected to the same feeder. Understand whether and how these controls cooperate with existing integrated voltage and VAR control systems.
- Evaluate the benefit of distributed voltage-reactive power controls at the distribution feeder level.
- Evaluate mitigation options required at the distribution feeder level to enable inverter reactive power based voltage control
- Conduct stakeholder process for inverter Volt-Var control functionalities consistent with IEEE 1547-2018 and the NC commission order.

Logistics

- Today's presentation will be distributed
- Clarifying questions will be answered during the presentation and stakeholder discussions at the end of the presentation
- Written feedback and comments will be solicited using comment form
- Comment form will be distributed along with presentation after the meeting
- Share the feedback form using email: Duke-IEEE1547@duke-energy.com for stakeholders to provide their written feedback

Volt-Var Functionality Study Project Timeline*



Stakeholder Meeting

Stakeholder Comment window

*This timeline may be adjusted based on filing requirements

Overview of Volt-Var Functionality Study

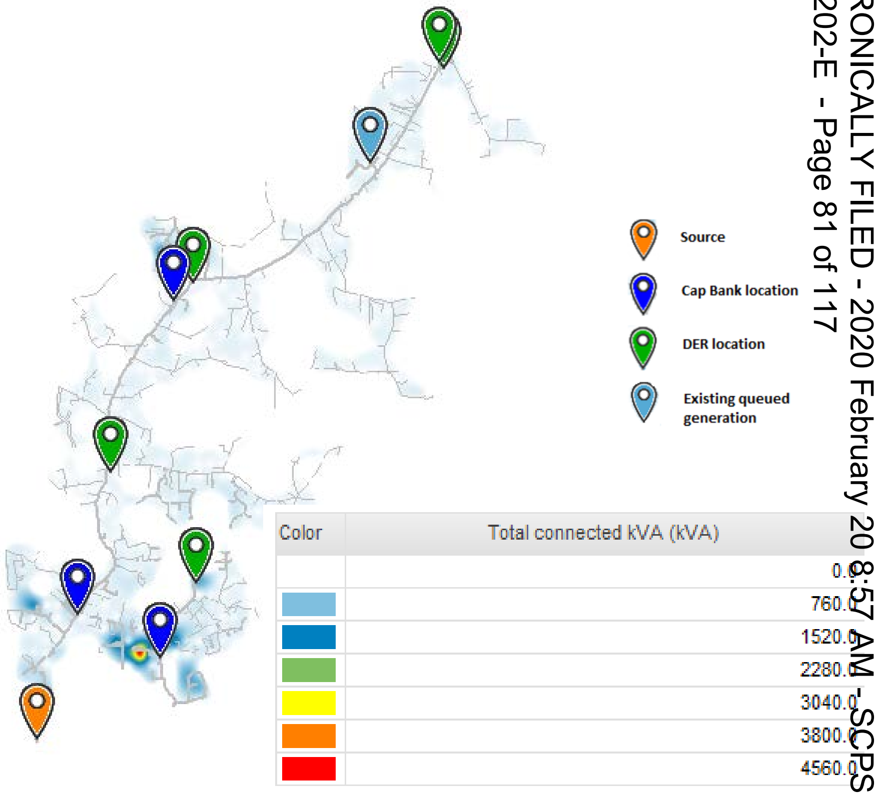
Tasks	1. Prepare Study	2. Conduct the Study and Stakeholder feedback	3. Final Deliverables
Key Steps	• Identify feeders, banks, and substations for testing • Collect input data and begin the model development process • Determine the number of controller configurations per feeder model • Power system model alignment that includes CYME	• Develop Scenarios • For the control settings determine approximate Var compensation magnitude and suggested source/equipment on high-level • Evaluate performance of Control functions using long rem dynamic analysis module • Obtain Stakeholder feedback	Developing a report that includes • DER volt-var optimization Results • Findings and recommendations

Inverter Volt-Var Functionality - Study (DEC System)

- Feeder description – Feeder A off-peak

Feeder load characteristics	Value
Total load KW	1606.9
Total load Kvar	425.6
load PF	96.7%
Total load KVA	1662.3
Total KVA (peak load)	13735.6
Total load as a % of peak load	12.1%

Generation*	Value
Existing queued generation (end of feeder)	336 KW
Generation with smart inverter capability modeled at the head section	4 MW
Generation with smart inverter capability modeled at the middle section	2 MW
Generation with smart inverter capability modeled at the end section	4 MW



*Each 2 MW DER has a +/- 0.9 PF capability. The DER is connected to the feeder via a 0.48/23.9kV, %Z=5.75 and X/R ratio of 8.24 step up transformer.

DER Ability to Control Voltage

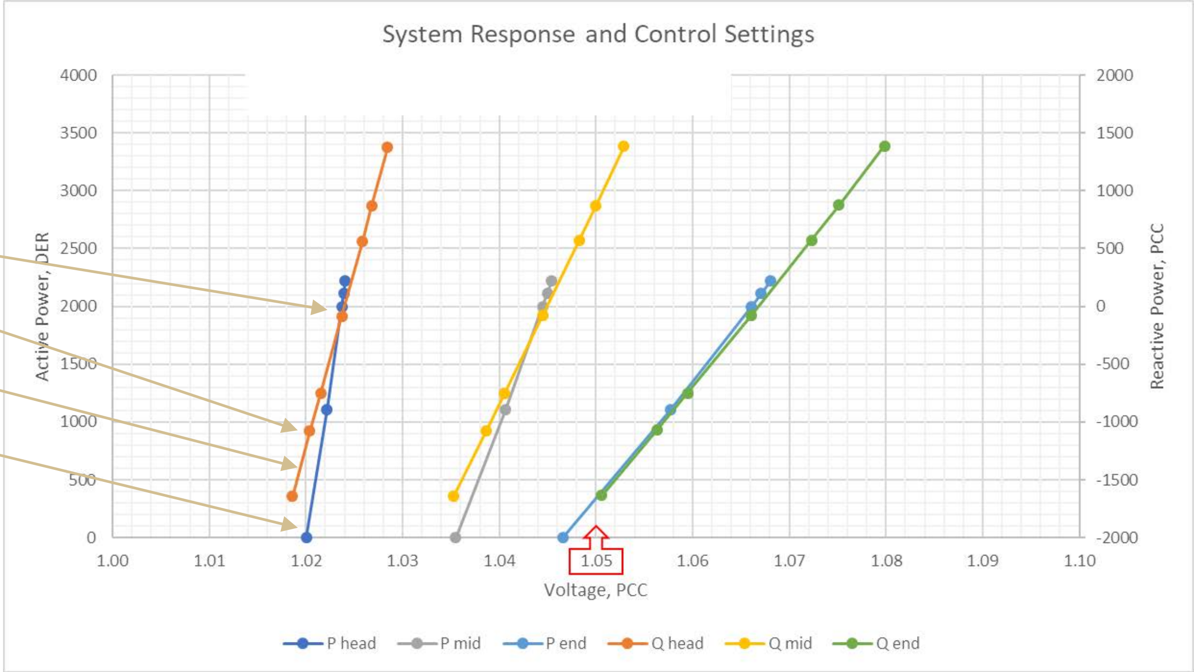
- Displays impact of injecting active and reactive power: dV/dP, dV/dQ
- Indicates there is limited ability to impact voltage and the ability changes based on location
- Worst case: vertical line
- Best case: horizontal line

Center at 2000 kW, 0 kVAR

0.9 pf point

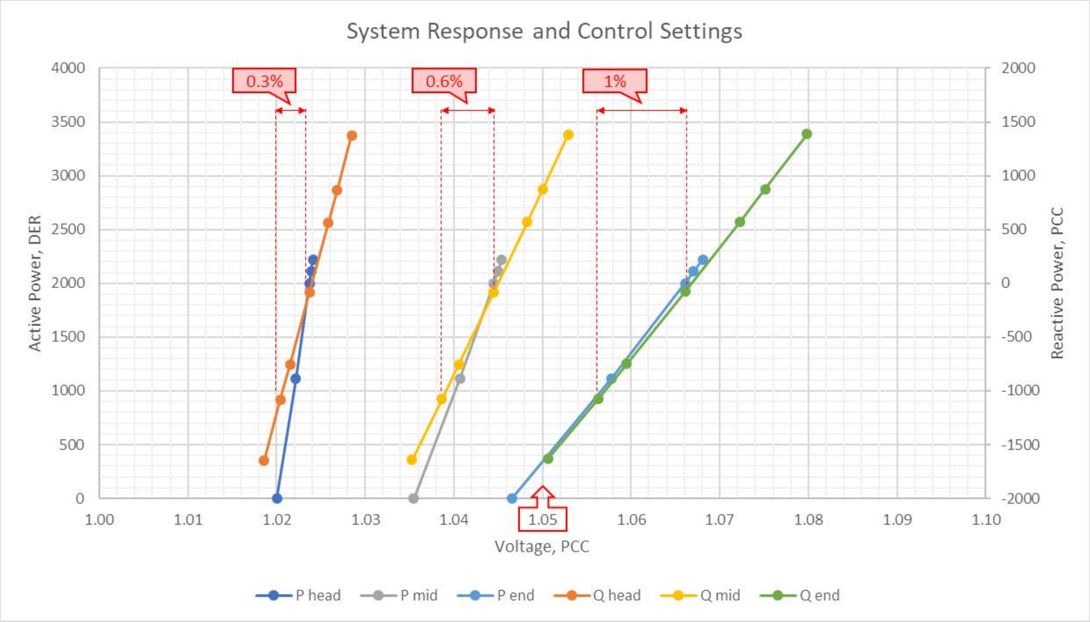
dQ line

dP line



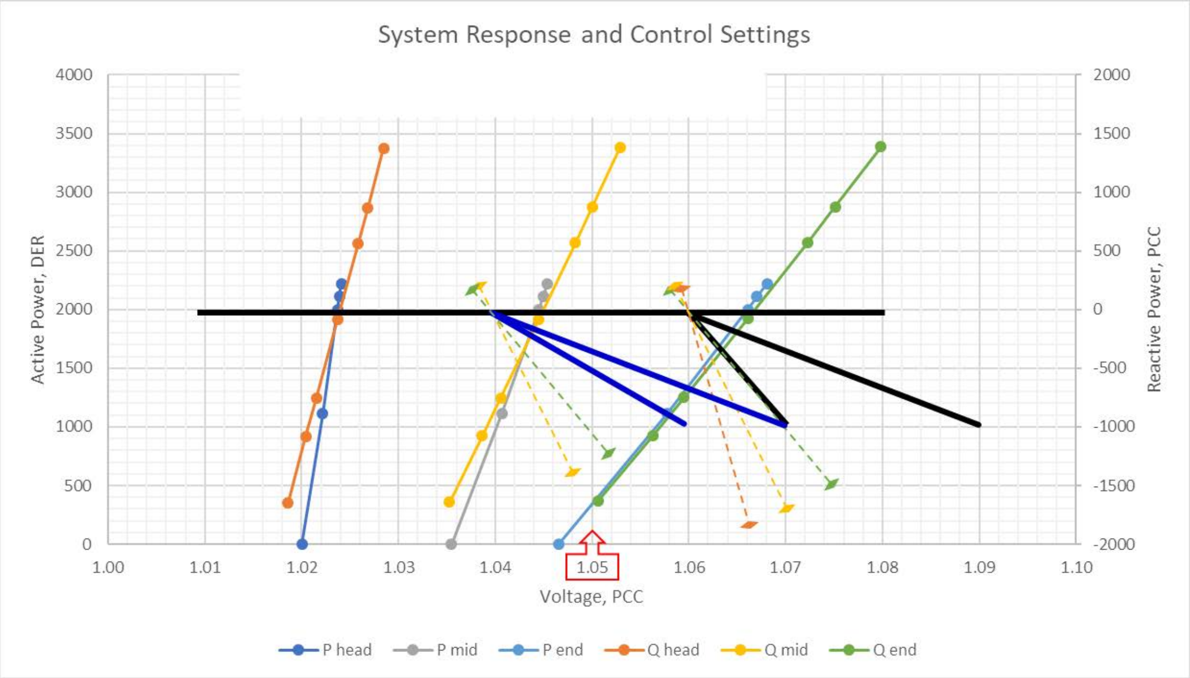
Initial Conclusions from Charts

- Reactive power voltage control is limited to 0.3 - 1.0 %; even at 0.9 pf operation
- Only one location exceeds 1.05 V pu at unity
  - So, at that location, volt-var has impact
  - At the other locations, watt-var more likely to work or even a non-unity pf
  - And volt-watt at end would be an option
- The system response varies between 0.3 – 1.0 % dV pu/dQmax
  - Not a large control range or impact
  - Input to consider for controller slope limit



Application to Settings

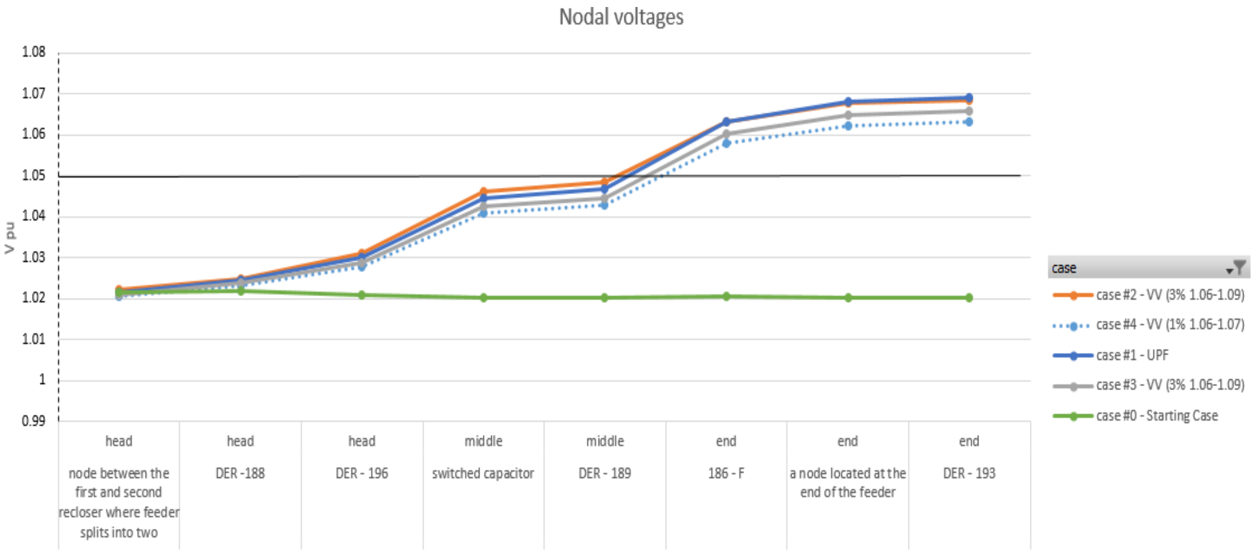
- Can add the controller lines directly on the chart
  - Deadband in the center, blue lines for 1.04 initiation, black lines for 1.06 initiation
- Controller slope options considered are shown
- Dashed lines represent the system response slopes; by color
- The goal is to keep the controller slope to the right of the system response



For Discussion Purposes Only

Inverter Volt-Var functionality – Study (DEC System Off Peak)

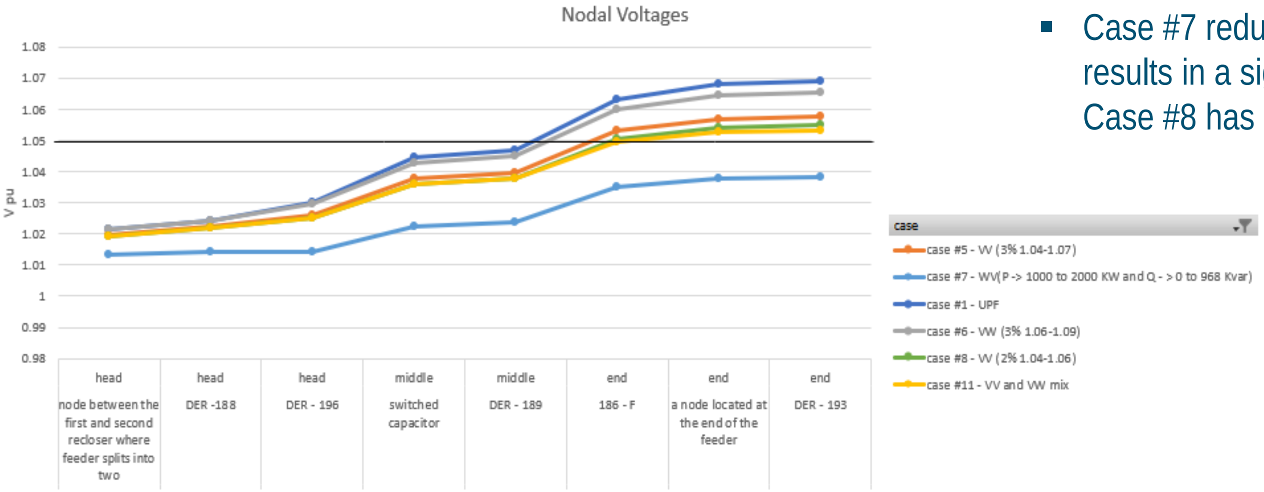
Cases	Caps	Number of DER units	Location	Control type	Control description	Gen outside 0.95 pf limit	Inverter KW	Kvar absorption at the PCC	Total_Kvar absorption at the PCC
case #1	900 Kvar (head)	5	head,middle,end	Unity Power Factor	100%	No	2000	-170,-82,-158	-410
case #2	900 Kvar (head), 900 Kvar(middle)	3	head,middle	Volt-Var	3% from 1.06 to 1.09	No	2000	-170,-82	
case #2	900 Kvar (head), 900 Kvar(middle)	2	end	Volt-Var	3% from 1.06 to 1.09	No	2000	-730	-982
case #3	900 Kvar (head)	3	head, middle	Volt-Var	3% from 1.06 to 1.09	No	2000	-170,-82	
case #3	900 Kvar (head)	2	end	Volt-Var	3% from 1.06 to 1.09	No	2000	-507	-759
case #4	900 Kvar (head)	3	head, middle	Volt-Var	1% from 1.06 to 1.07	No	2000	-170,-82	
case #4	900 Kvar (head)	2	end	Volt-Var	1% from 1.06 to 1.07	No	2000	-784	-1036



- Case #4 was studied after reviewing results of Case #3.
- Case #4 has a better voltage response but still doesn't mitigate overvoltage.

Inverter Volt-Var functionality – Study (DEC System Off Peak)

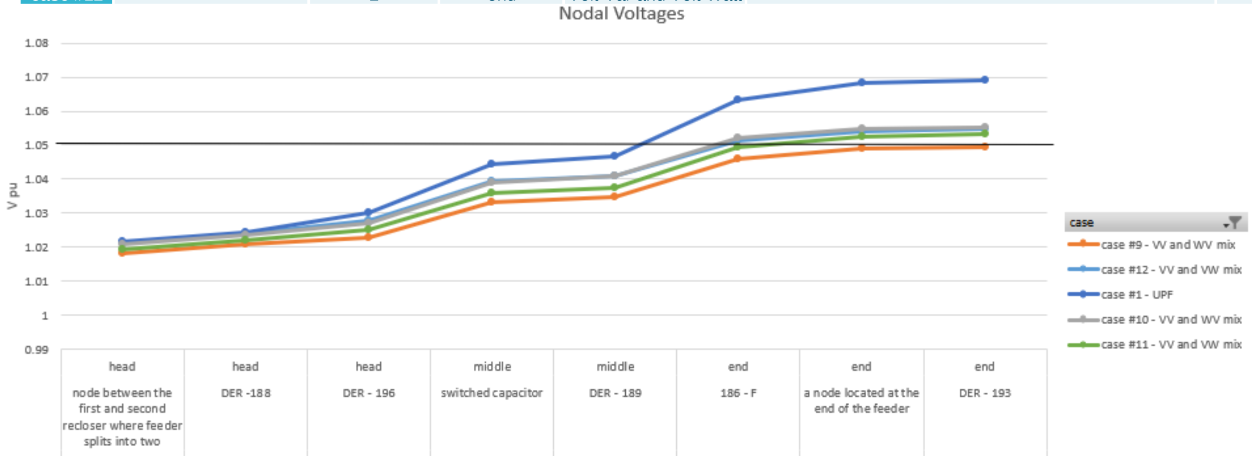
Cases	Caps	Number of DER units	Location	Control type	Control description	Gen outside 0.95 pf limit	Inverter_KW	Kvar absorption at the PCC	Total_Kvar absorption at the PCC
case #5	900 Kvar (head)	2	head	Volt-Var	3% from 1.04 to 1.07	No	2000	-170	-1696
case #5	900 Kvar (head)	1	middle	Volt-Var	3% from 1.04 to 1.07	No	2000	-190	
case #5	900 Kvar (head)	2	end	Volt-Var	3% from 1.04 to 1.07	No	2000	-1336	
case #6	900 Kvar (head)	3	head,middle	Volt-Watt	3% from 1.06 to 1.09	No	2000	-170,-82	-379
case #6	900 Kvar (head)	2	end	Volt-Watt	3% from 1.06 to 1.09	No	1793	-127	
case #7	900 Kvar (head)	5	head,middle,end	Watt-Var	P->1000 to 2000 KW and Q->0 to 968 Kvar	Yes	2000	-2162,-1079,-2150	-5391
case #8	900 Kvar (head)	2	head	Volt-Var	2% from 1.04 to 1.06	No	2000	-170	-1938
case #8		1	middle	Volt-Var	2% from 1.04 to 1.06	No	2000	-148	
case #8	900 Kvar (head)	2	end	Volt-Var	2% from 1.04 to 1.06	Yes	2000	-1620	



- Case #7 reduces voltage below 1.05 pu, but results in a significant reactive power absorption. Case #8 has a better voltage response.

Inverter Volt-Var functionality – Study (DEC System Off Peak)

Cases	Caps	Number of DER units	location	Control type	Control description	Gen outside 0.95 pf limit	Inverter_KW	Kvar absorption at the PCC	Total_Kvar absorption at the PCC
case #9	900 Kvar (head)	2	head	Volt-Var	2% from 1.04 to 1.06	No	2000	-172	-2412
case #9		1	middle	Volt-Var	2% from 1.04 to 1.06	No	2000	-97	
case #9		2	end	Watt-Var	P->1000 to 2000 KW and Q->0 to 968 Kvar	Yes	2000	-2143	
case #10	2400 Kvar (head), 900 Kvar (middle)	2	head	Volt-Var	2% from 1.04 to 1.06	No	2000	-170	-2432
case #10		1	middle	Volt-Var	2% from 1.04 to 1.06	No	2000	-115	
case #10		2	end	Watt-Var	P->1000 to 2000 KW and Q->0 to 968 Kvar	Yes	2000	-2147	
case #11	900 Kvar (head)	2	head	Volt-Var	2% from 1.04 to 1.06	No	2000	-170	-1671
case #11		1	middle	Volt-Var	2% from 1.04 to 1.06	No	2000	-122	
case #11		2	end	Volt-Var and Volt-Watt	volt-var: 2% 1.04 to 1.06 and volt-watt - 2% 1.05 to 1.07	No	1816	-1379	
case #12	1700 Kvar (head), 900 Kvar (middle)	2	head	Volt-Var	2% from 1.04 to 1.06	No	2000	-186	-1929
case #12		1	middle	Volt-Var	2% from 1.04 to 1.06	No	2000	-195	
case #12		2	end	Volt-Var and Volt-Watt	volt-var: 2% 1.04 to 1.06 and volt-watt - 2% 1.05 to 1.07	Yes	1702	-1548	



- Case #9 provides the most optimal response and reduce voltage below 1.05 pu.
- However, Case #9 has an 800 KVAR higher reactive requirement than Case #11.

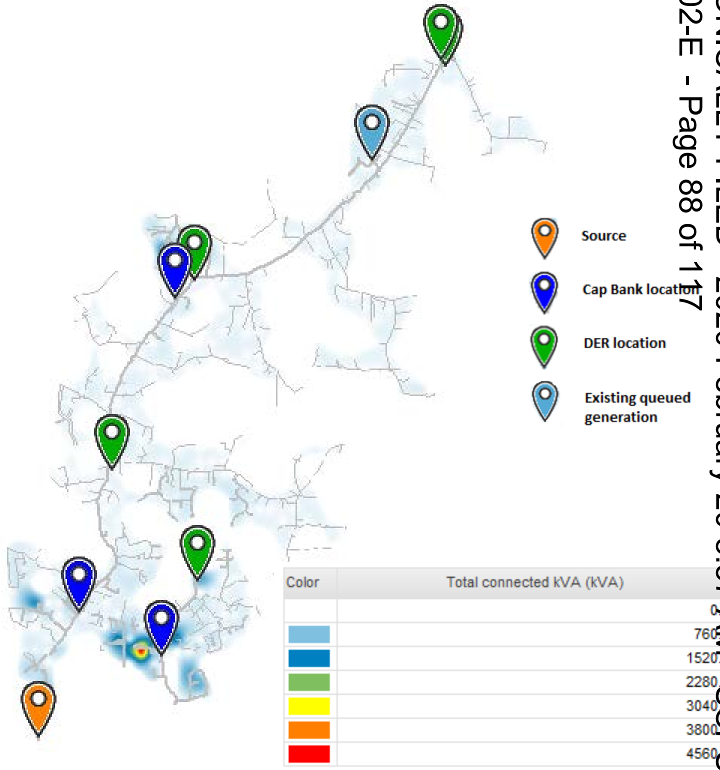
Inverter Volt-Var functionality – Study (DEC System Shoulder Peak)

- Feeder description – Feeder A shoulder peak

Feeder load characteristics	Value
Total load KW	8879.7
Total load Kvar	2105.4
load PF	97.3%
Total load KVA	9125.9
Total KVA (peak load)	13735.6
Total load as a % of peak load	66.4%

Generation*	Value
Existing queued generation (end of feeder)	336 KW
Generation with smart inverter capability modeled at the head section	4 MW
Generation with smart inverter capability modeled at the middle section	2 MW
Generation with smart inverter capability modeled at the end section	4 MW

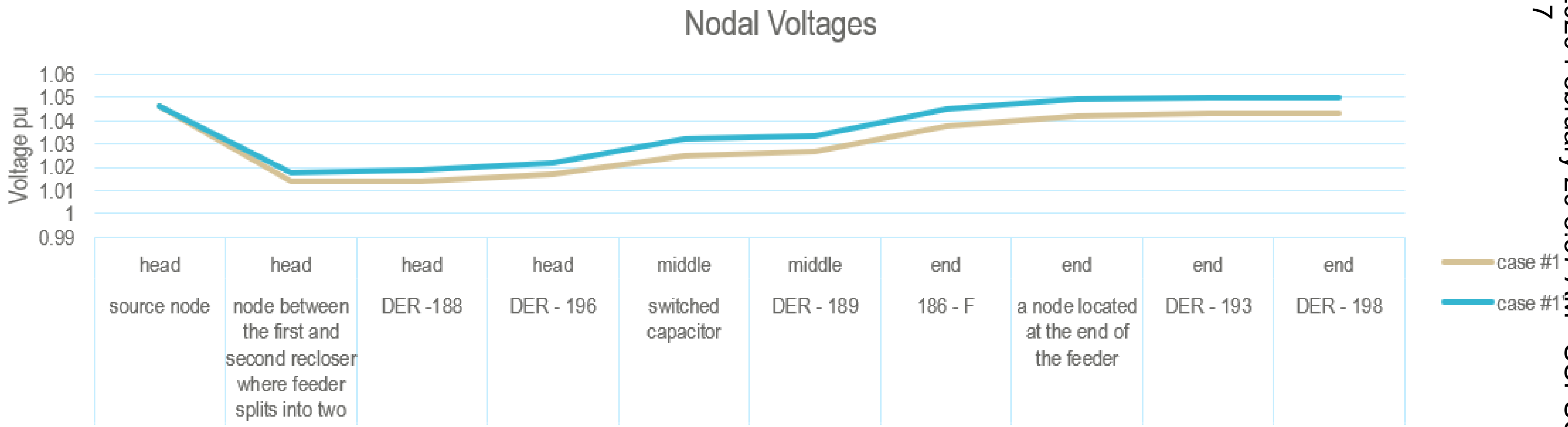
*Each 2 MW DER has a +/- 0.9 PF capability. The DER is connected to the feeder via a 0.48/23.9kV, %Z=5.75 and X/R ratio of 8.24 step up transformer.



Inverter Volt-Var Functionality – Study (DEC System Shoulder Peak)

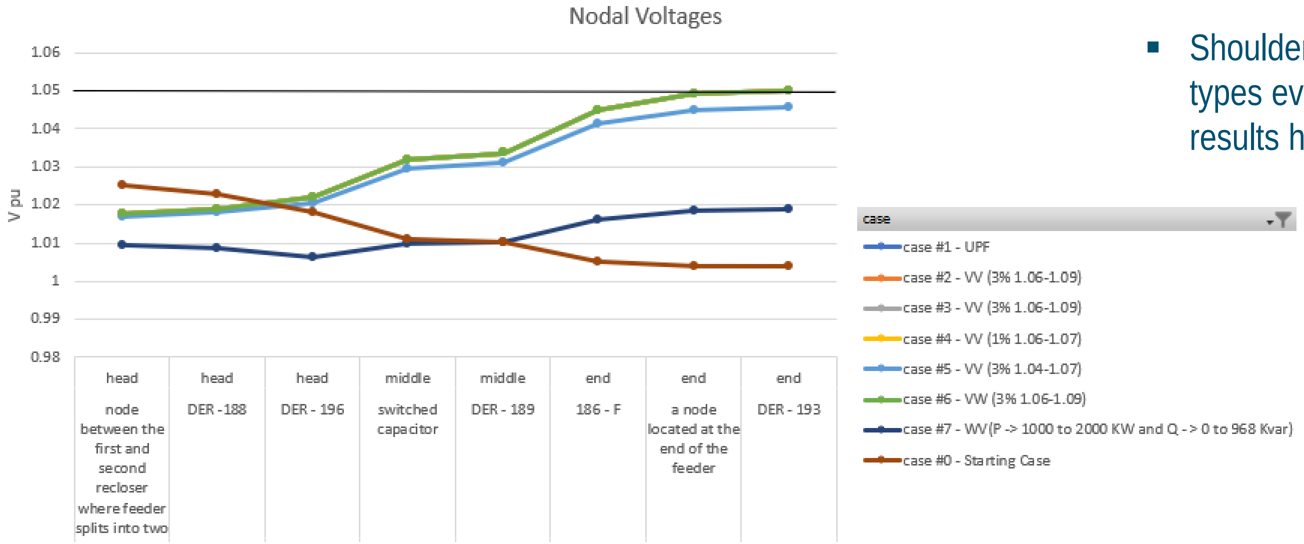
- Case Description – shoulder peak

Case	Caps	Regulator	Location	Control Type	Control Outline
case #1	offline	-5,-6,-4	head,middle and end	unity power factor	Unity power factor
case #1’	900 Kvar (head), 600 Kvar (head), 900 Kvar (middle)	-5,-6,-4	head,middle and end	unity power factor	Unity power factor



Inverter Volt-Var functionality – Study (DEC System Shoulder Peak)

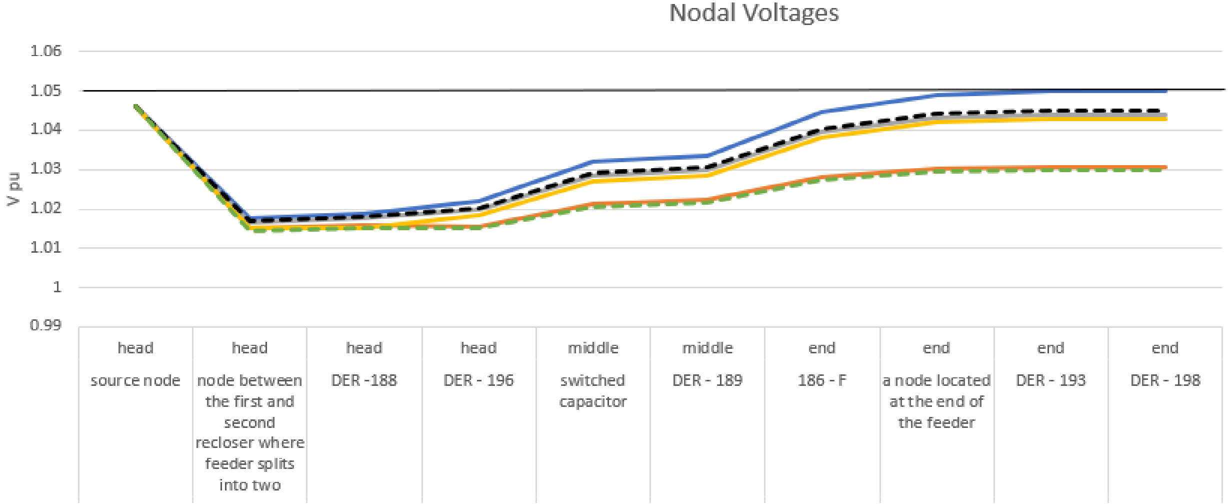
Case	Caps	Number of DER units	Location	Control type	Control description	gen outside 0.95 pf limit	Inverter_KW	Kvar absorption at the PCC	Total Kvar absorption at the PCC
case #1	1500 Kvar (head), 900 Kvar (middle)	5	head,middle,end	Unity Power Factor	100%	No	2000	-170,-82,-158	-410
case #2, #3, #4	1500 Kvar (head), 900 Kvar (middle)	3	head,middle,end	Volt-Var	3% from 1.06 to 1.09	No	2000	-170,-82,-158	-410
case #5	1500 Kvar (head), 900 Kvar (middle)	3	head,middle	Volt-Var	3% from 1.04 to 1.07	No	2000	-170,-84	-826
case #5	1500 Kvar (head), 900 Kvar (middle)	2	end	Volt-Var	3% from 1.04 to 1.07	No	2000	-572	
case #6	1500 Kvar (head), 900 Kvar (middle)	5	head,middle,end	Volt-Watt	3% from 1.06 to 1.09	No	2000	-170,-82,-158	-410
case #7	1500 Kvar (head), 900 Kvar (middle)	5	head,middle,end	Watt-Var	P->1000 to 2000 KW and Q->0 to 968 Kvar	Yes	2000	--2162,-1079,-2158	-5399



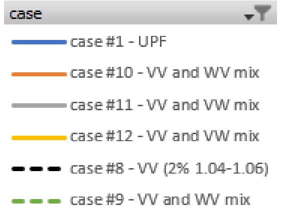
- Shoulder peak cases were tested for control types evaluated for the off-peak case to see if results hold true in the shoulder peak case

Inverter Volt-Var functionality – Study (DEC System Shoulder Peak)

Case	Caps	Number of DER units	location	Control type	Control description	Gen outside 0.95 pf limit	Inverter_KW	Kvar absorption at the PCC	Total_Kvar absorption at the PCC
case #8	1500 Kvar (head), 900 Kvar (middle)	3	head,middle	Volt-Var	2% from 1.04 to 1.06	No	2000	-170,-148	-978
case #8	1500 Kvar (head), 900 Kvar (middle)	2	end	Volt-Var	2% from 1.04 to 1.06	No	2000	-660	
case #9	1500 Kvar (head), 900 Kvar (middle)	3	head,middle	Volt-Var	2% from 1.04 to 1.06	No	2000	-172,-86	-2412
case #9	1500 Kvar (head), 900 Kvar (middle)	2	end	Watt-Var	P->1000 to 2000 KW and Q->0 to 968 Kvar	Yes	2000	-2154	
case #10	3900 Kvar (head), 900 (middle)	3	head,middle	Volt-Var	2% from 1.04 to 1.06	No	2000	-172,-86	-2412
case #10	3900 Kvar (head), 900 (middle)	2	end	Watt-Var	P->1000 to 2000 KW and Q->0 to 968 Kvar	Yes	2000	-2154	
case #11	1500 Kvar (head), 900 Kvar (middle)	3	head,middle	Volt-Var	2% from 1.04 to 1.06	No	2000	-170,-148	-978
case #11	1500 Kvar (head), 900 Kvar (middle)	2	end	Volt-Var and Volt-Watt	volt-var: 2% 1.04 to 1.06 and volt-watt - 2% 1.05 to 1.07	No	2000	-660	
case #12	2500 Kvar (head), 900 (middle)	3	head,middle	Volt-Var	2% from 1.04 to 1.06	No	2000	-170,148	-1030
case #12	2500 Kvar (head), 900 (middle)	2	end	Volt-Var and Volt-Watt	volt-var: 2% 1.04 to 1.06 and volt-watt - 2% 1.05 to 1.07	No	2000	-712	



- The results indicate, control setpoint picked for off-peak would work for shoulder-peak as well.
- The reactive compensation is also set by the off-peak case

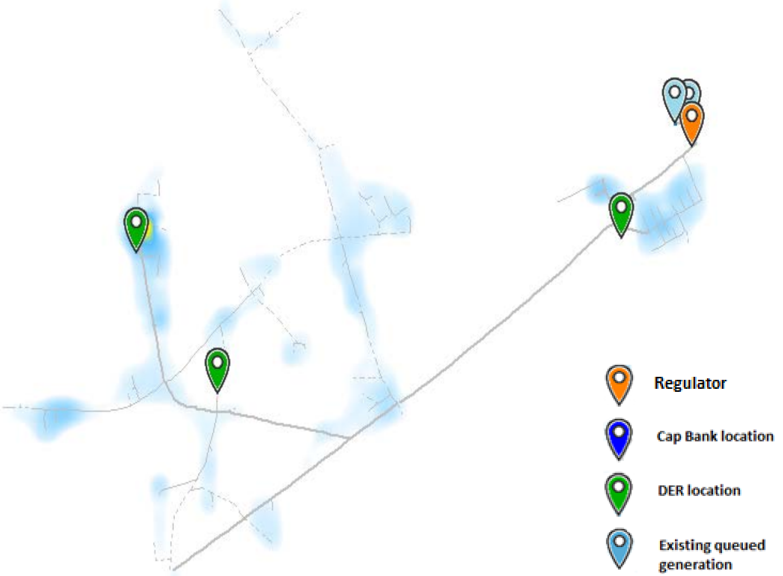


Inverter Volt-Var functionality - Study (DEP System Off-Peak)

- Feeder B description – off-peak

Feeder load characteristics	Value
Total load KW	252.2
Total load Kvar	94.7
load PF	94.0%
Total load KVA	269.4
Total KVA (peak load)	7103.8
Total load as a % of peak load	3.8%

Generation*	Value
Existing queued generation (head of the feeder)	10 MW
Generation with smart inverter capability modeled at the head section	2 MW
Generation with smart inverter capability modeled at the middle section	2 MW
Generation with smart inverter capability modeled at the end section	2 MW

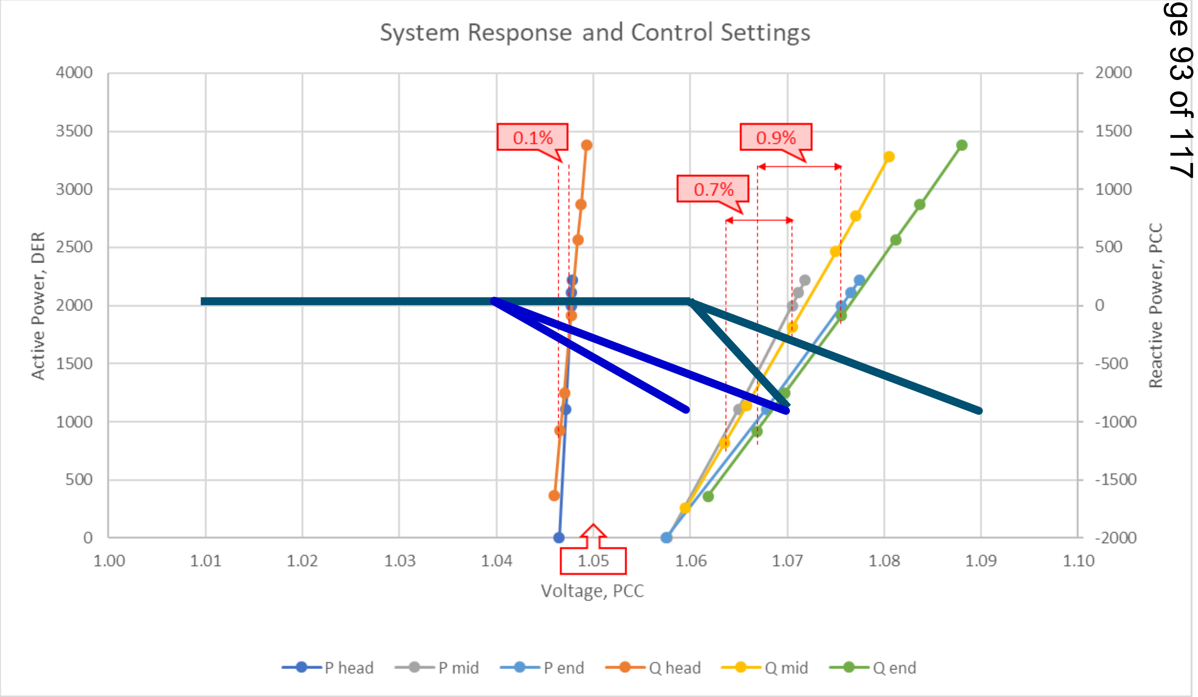


Color	Total connected kVA (kVA)
	0.0
light blue	178.3
yellow	356.7
red	535.0

*Each 2 MW DER has a +/- 0.9 PF capability. The DER is connected to the feeder via a 0.48/23.9kV, %Z=5.75 and X/R ratio of 8.24 step up transformer.

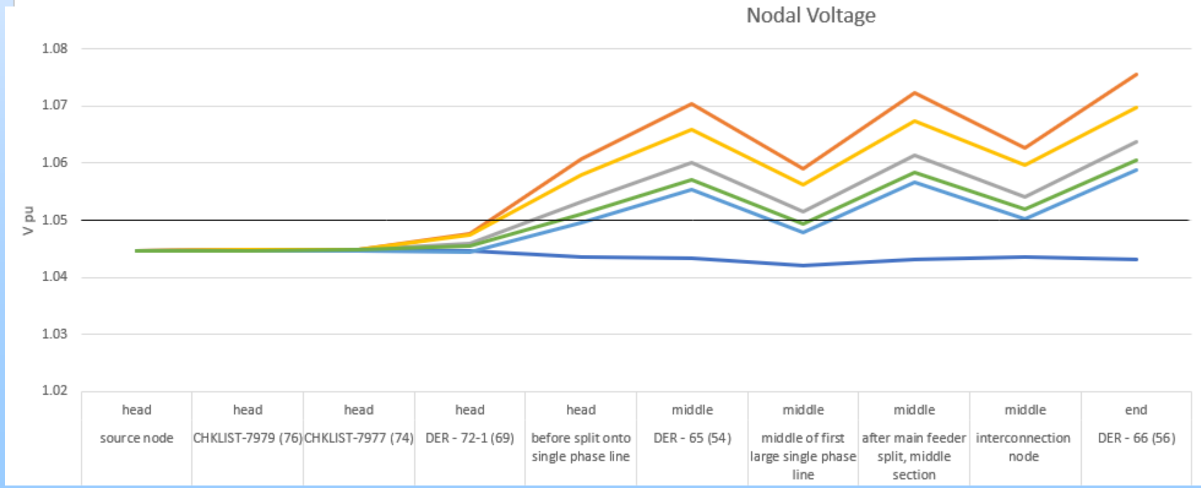
Application to Settings

- The response at the end of the feeder is similar to the previous circuit
- The response at the head is much lower
- The last two controllers are electrically close, that indicates similar controls should be effective
- Given the voltage at the head, the first DER is likely to operate absorbing
- The last two DER are expected to operate near reactive limit

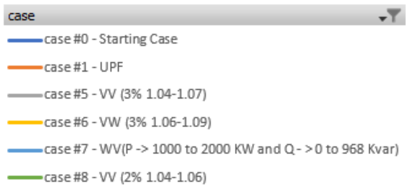


Inverter Volt-Var functionality – Study (DEP System Off-Peak)

Case	Caps	Number of DER units	Location	Control type	control outline	gen outside 0.95 pf limit	Inverter_KW	Kvar absorption at the PCC	total Kvar
case #1	none	3	head,middle,end	Unity Power Factor	Unity Power Factor	No	2000	-82,-78,-86	-246
case #5	none	1	head	volt-var	3% from 1.04 to 1.07	No	2000	-276	
case #5	none	1	middle	volt-var	3% from 1.04 to 1.07	No	1999	-744	-1897
case #5	none	1	end	volt-var	3% from 1.04 to 1.07	Yes	1999	-877	
case #6	none	1	head	volt-watt	3% from 1.06 to 1.09	No	2000	-82	
case #6	none	1	middle	volt-watt	3% from 1.06 to 1.09	No	1769	-63	-198
case #6	none	1	end	volt-watt	3% from 1.06 to 1.09	No	1490	-53	
case #7	none	3	head,middle,end	watt-var	P_1000->2000kW Q_0-928kVAR or 0.9 pf	Yes	2000	-1075,-1072,-1078	-3225
case #8	none	1	head	volt-var	2% from 1.04 to 1.06	No	2000	-347	
case #8	none	1	middle	volt-var	2% from 1.04 to 1.06	Yes	1999	-923	-2341
case #8	none	1	end	volt-var	2% from 1.04 to 1.06	Yes	1999	-1071	

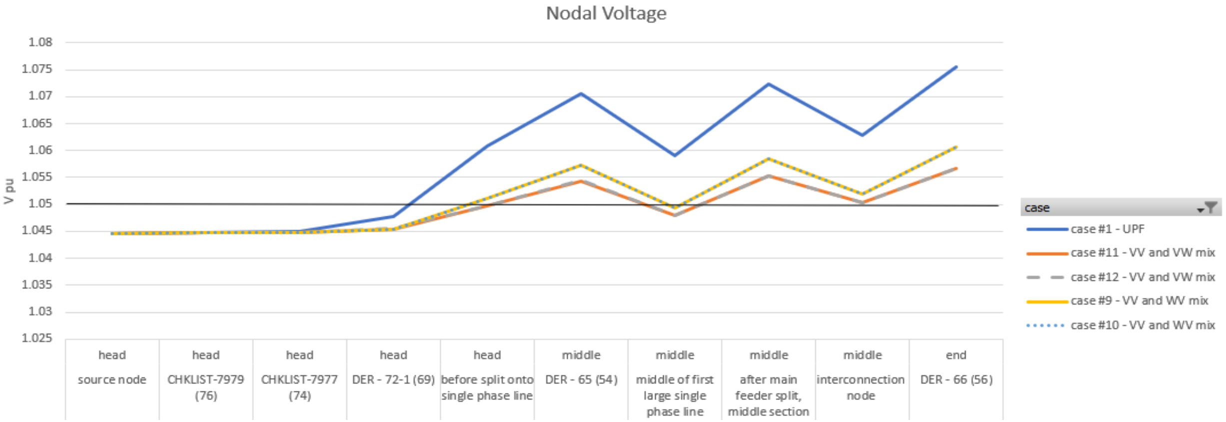


- Control setpoints evaluated for Feeder A were also evaluated for Feeder B. As expected, Case #7 reduces voltages the most but has a very high reactive power absorption. Case #8 has a better response.



Inverter Volt-Var functionality – Study (DEP System Off-Peak)

Case	Caps	Number of DER units	Location	control type	control outline	gen outside 0.95 pf limit	Inverter_KW	Kvar absorption at the PCC	total Kvar
case #9	none	1	head	volt-var	2% from 1.04 to 1.06	No	2000	-346	-2341
case #9	none	1	middle	volt-var	2% from 1.04 to 1.06	Yes	1999	-923	
case #9	none	1	end	watt-var	P_1000->2000kW Q_0-928kVAR or 0.9 pf	Yes	1999	-1072	
case #10	2400 Kvar (head)	1	head	volt-var	2% from 1.04 to 1.06	No	2000	-346	-2341
case #10	2400 Kvar (head)	1	middle	volt-var	2% from 1.04 to 1.06	Yes	1999	-923	
case #10	2400 Kvar (head)	1	end	watt-var	P_1000->2000kW Q_0-928kVAR or 0.9 pf	Yes	1999	-1072	
case #11	none	1	head	volt-var and volt-watt	volt-var: 2% from 1.04 to 1.06 and volt-watt - 2% from 1.05 to 1.07	No	2000	-352	-1934
case #11	none	1	middle	volt-var and volt-watt	volt-var: 2% from 1.04 to 1.06 and volt-watt - 2% from 1.05 to 1.07	Yes	1679	-752	
case #11	none	1	end	volt-var and volt-watt	volt-var: 2% from 1.04 to 1.06 and volt-watt - 2% from 1.05 to 1.07	Yes	1449	-830	
case #12	2000 Kvar (head)	1	head	volt-var and volt-watt	volt-var: 2% from 1.04 to 1.06 and volt-watt - 2% from 1.05 to 1.07	No	2000	-352	-1934
case #12	2000 Kvar (head)	1	middle	volt-var and volt-watt	volt-var: 2% from 1.04 to 1.06 and volt-watt - 2% from 1.05 to 1.07	Yes	1679	-752	
case #12	2000 Kvar (head)	1	end	volt-var and volt-watt	volt-var: 2% from 1.04 to 1.06 and volt-watt - 2% from 1.05 to 1.07	Yes	1449	-830	



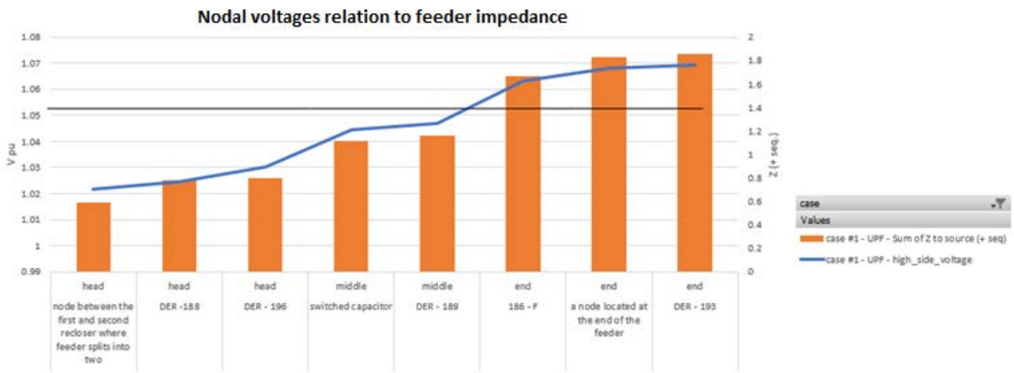
- Case #9 and Case #11 have better voltage responses. Case #11 reduces active power, whereas Case#9 results in an additional 400 KVAR reactive power absorption as compared to Case #11.

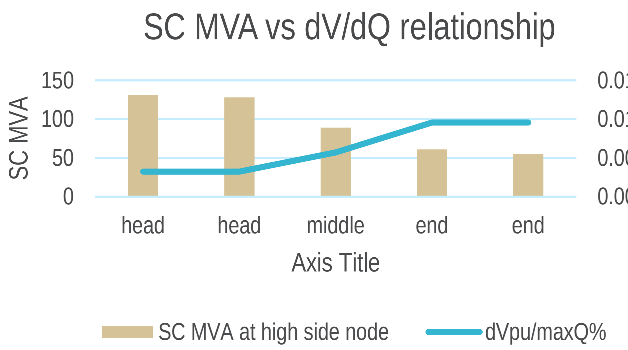
Inverter Volt-Var functionality

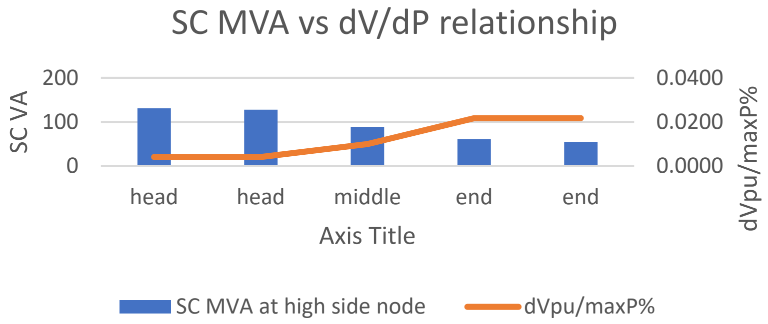
- Summary of Results:
  - The control settings evaluated for Feeder A were also evaluated for Feeder B.
  - Study indicates a standalone volt-var controller is not sufficient to mitigate voltage issues for DER units at the end of the feeder. dP/dV and dQ/dV curves confirm this result as well.
  - dP/dV and dQ/dV curves also indicate limited voltage control would be available for units at the head of the feeder.
  - Volt-Var control in combination with Volt-Watt control or a standalone Watt-Var controller could work for units at the end of the feeder.
  - Universal controller could work:
    - Best controller for Feeder A off-peak would also work for Feeder A shoulder-peak and other loading conditions.
    - The same controller for Feeder A could work for Feeder B. Studies on additional feeders would give an indication on this.

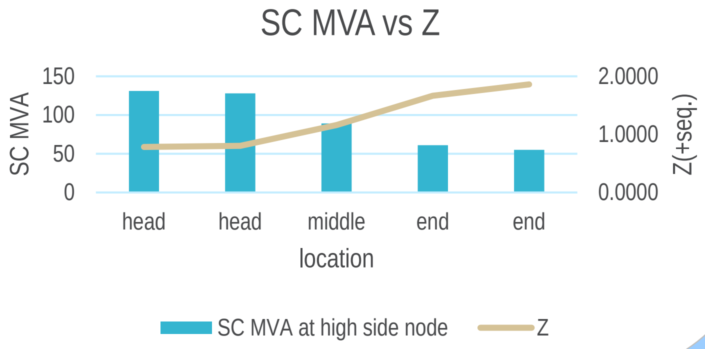
Inverter Volt-Var Functionality

- Come up with control strategies based on generation and feeder characteristics, for example feeder impedance values, X/R ratio, short circuit MVA at PCC.









Inverter Volt-Var functionality – Next Steps

- Incorporate stakeholder feedback into these first 2 feeders
- Set up the testing parameters for the remaining 4 feeders.
- Apply dV/dP and dV/dQ calculations in determining appropriate control methodology and control settings.
- For the optimized control settings determine approximate Var compensation magnitude and suggested source/equipment on high-level (if any needed) to maintain the power factor (or reactive power) at the feeder and bank level.
  - Provide reactive compensation equal to the reactive power absorbed at the DER PCC
- Evaluate if a universal controller is effective for all the circuits.
- Set the long-term dynamic profiles with the identified load and irradiance profiles and simulate test days with the optimized control settings.

Stakeholder Feedback Form

Topic	Stakeholder	Comments	Proposals

Attachment I

Action Plan to Implement 1547

Anthony C Williams, P.E.
Principal Engineer

DER Technical Standards

January 21, 2020

DUKE ENERGY

Agenda

- How to prioritize or order IEEE 1547 requirements
  - Interconnection related
  - Priority and complexity
- Review Duke Evaluation of the order
- Conduct stakeholder process for implementing various aspects of the IEEE 1547-2018 standard
  - Stakeholder feedback and input
  - Poll

Note: North Carolina Commission tasked Duke to evaluate the costs and benefits of implementing various aspects of the IEEE 1547-2018 standard and file a report with the Commission by April 1, 2020

Ground Rules

- All Stakeholder Group meetings, webinars and information exchange are designed solely to provide an open forum or means for the expression of various points of view in compliance with antitrust laws.
- Under no circumstances shall Stakeholder Group activities be used as a means for competing companies to reach any understanding, expressed or implied, which tends to restrict competition, or in any way, to impair the ability of participating members to exercise independent business judgment regarding matters affecting competition or regulatory positions.
- Proprietary information shall not be disclosed by any participant during any group meetings. In addition, no information of a secret or proprietary nature shall be made available to Stakeholder Group members.
- All proprietary information which may nonetheless be publicly disclosed by any participant during any group meeting shall be deemed to have been disclosed on a non-confidential basis, without any restrictions on use by anyone, except that no valid copyright or patent right shall be deemed to have been waived by such disclosure.

Logistics

- Today's presentation will be distributed
- Clarifying questions will be answered during the presentation and stakeholder discussions at the end of the presentation
- Written feedback and comments will be solicited using comment form
- Comment form will be distributed along with presentation after the meeting
- Share the feedback form using email: Duke-IEEE1547@duke-energy.com for stakeholders to provide their written feedback

Priority and Complexity

High

Medium

Low

1. Functions that enable higher penetrations of DER
2. Rank topics based on stakeholder preference
3. Note that there will be a need to spread the more complex functions over time

Complex

Detailed

Basic

Interconnection Related Functions

- Past TSRG input -- Functions that enable higher penetrations of DER
- The following functions in 1547 improve the capability of DER to interconnect:
  - 5.2 Reactive power capability of the DER
  - 5.3 Voltage and reactive power control
    - 5.3.2 Constant power factor mode
    - 5.3.3 Voltage-reactive power mode
    - 5.3.4 Active power-reactive power mode
    - 5.3.5 Constant reactive power mode
  - 5.4 Voltage and active power control
    - 5.4.2 Voltage-active power mode
  - 4.6.2 Capability to limit active power

Interconnection Function Status

- Active evaluations
  - Starting with 5.3 Voltage and reactive power control
    - By necessity then, 5.2 Reactive power capability of the DER
  - Secondary focus on 5.4 Voltage and active power control
- Future evaluation
  - 4.6.2 Capability to limit active power
    - In a way, done now by restricting kW at SIS
    - Performing this during real time operations is complex
      - Implementation would need considerable investigation
- Three of these four more important functions are in progress

Duke Evaluated Order

IEEE 1547 Basic Functions and Requirements

- S4.1 – 4.6: General
  - 4.1 Introduction
  - 4.2 Reference points of applicability (RPA) [Interconnection]
  - 4.3 Applicable voltages [Manufacturer]
  - 4.4 Measurement accuracy [Manufacturer]
  - 4.5 Cease to energize performance requirement [Reliability]
  - 4.6 Control capability requirements
    - 4.6.1 Capability to disable permit service [Reliability]
    - 4.6.3 Execution of mode or parameter changes [Manufacturer]
- S4.8 – 4.10: General
  - 4.8 Isolation device [Interconnection]
  - 4.9 Inadvertent energization of the Area EPS [Interconnection]
  - 4.10 Enter service [Reliability]

Duke Evaluated Order

IEEE 1547 Technical Functions and Requirements

- S6: Response to Area EPS abnormal conditions
  - 6.2 Area EPS faults and open phase conditions [Reliability]
  - 6.3 Area EPS reclosing coordination [Reliability]
  - 6.4 Voltage [Reliability]
    - 6.4.1 Mandatory voltage tripping requirements
    - 6.4.2 Voltage disturbance ride-through requirements
    - ⋮
    - 6.4.2.6 Dynamic voltage support

Duke Evaluated Order

IEEE 1547 Technical Functions and Requirements

- S6: Response to Area EPS abnormal conditions
  - 6.5 Frequency [Reliability]
    - 6.5.1 Mandatory frequency tripping requirements
    - 6.5.2 Frequency disturbance ride-through requirements
    - ⋮
    - 6.5.2.5 Rate of change of frequency (ROCOF) ride-through
    - 6.5.2.6 Voltage phase angle changes ride-through
    - 6.5.2.7 Frequency-droop (frequency-power)
  - 6.6 Return to service after trip [Reliability]
- S8: Islanding [Reliability]
  - 8.1 Unintentional islanding
  - 8.2 Intentional islanding

Duke Evaluated Order

IEEE 1547 Technical Functions and Requirements

- S4.7: Prioritization of DER responses [Manufacturer]
- S4.11 – 4.13: General
  - 4.11 Interconnect integrity [Reliability]
  - 4.12 Integration with Area EPS grounding [Reliability]
  - 4.13 Exemptions for Emergency Systems and Standby DER [Reliability, Interconnection]
- S7: PQ [Reliability, Interconnection]
- 11.4 Fault current characterization

- S9: Secondary network [no networks in Carolinas]

Duke Evaluated Order

IEEE 1547 Information and Interoperability Requirements

- S10.1 – 10.4: Information Exchange and Models [Reliability (as required for a reliably function), Interconnection]
  - 10.1 Interoperability requirements
  - 10.2 Monitoring, control, and information exchange requirements
  - 10.3 – 10.6 DER Information
  - 10.7 Communication protocol requirements
  - 10.8 Communication performance requirements
  - 10.9 Cyber security requirements
- S11: Test and verification [Interconnection]
  - Design, Installation, Commissioning, Commissioning, Periodic tests and verifications

Poll Instructions

- After the meeting, complete the poll to prioritize the list
- Submit to Duke

1547 Section	Topic	Duke Order	Section Poll
4.2	Reference points of applicability (RPA) [Interconnection]	3	
4.3	Applicable voltages [Manufacturer]	3	
4.5	Cease to energize performance requirement [Reliability]	3	
4.6.1	Capability to disable permit service	21	
4.6.2	Capability to limit active power	21	
4.6.3	Execution of mode or parameter changes [Manufacturer]	9	
4.7	Prioritization of DER responses	22	
4.8	Isolation device [Interconnection]	23	
4.9	Inadvertent energization of the Area EPS [Interconnection]	8	
4.10	Enter service [Reliability] // 6.6 Return to service after trip	2	
4.10.2	Enter service criteria	2	
4.10.3	Performance during entering service	2	

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Stakeholder Feedback Form

Topic	Stakeholder	Comments	Proposals

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Discussion

- Are the proper IEEE 1547-2018 functions or requirements?
- Is the proposed order the proper order?
- By what process should the remaining items be prioritized or ordered, the poll?
- What should the development and implementation schedule look like?
- Is the TSRG the proper stakeholder membership

- Is it right that Interoperability and Communication be established early on to facilitate the other functions, data, and monitoring?
- Is it right that Test and Verification requirements be developed incrementally as the function and requirements are implemented?

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Attachment J

RANKING OF IEEE 1547-2018 FUNCTIONALITIES

Chapter Poll - Ranks from 1 through 5 (most to least important)

Section Poll - Ranks from 1 through 51 (most to least important, there can be multiple sections in each rank at this time)

Send the comments by email to Duke-IEEE1547@duke-energy.com

IEEE 1547 Section	Topic	Duke Order	Section Poll (Rank 1 through 51)	Chapter Poll (Rank 1 through 5)
4.2	Reference points of applicability (RPA) [Interconnection]	3		
4.3	Applicable voltages [Manufacturer]	3		
4.5	Cease to energize performance requirement [Reliability]	3		
4.6.1	Capability to disable permit service	21		
4.6.2	Capability to limit active power	21		
4.6.3	Execution of mode or parameter changes [Manufacturer]	9		
4.7	Prioritization of DER responses	22		
4.8	Isolation device [Interconnection]	23		
4.9	Inadvertent energization of the Area EPS [Interconnection]	8		
4.10	Enter service [Reliability] // 6.6 Return to service after trip	2		
4.10.2	Enter service criteria	2		
4.10.3	Performance during entering service	2		
4.10.4	Synchronization	2		
4.11.1	Protection from electromagnetic interference	24		
4.11.2	Surge withstand performance	24		
4.11.3	Paralleling device	5		
4.12	Integration with Area EPS grounding [Reliability]	25		
4.13	Exemptions for Emergency Systems and Standby DER	31		
5.2	**Reactive power capability of the DER**	1		
5.3	**Voltage and reactive power control**	1		
5.4.2	**Voltage-active power control**	1		
6.2	Area EPS faults and open phase conditions [Reliability]	5		
6.3	Area EPS reclosing coordination [Reliability]	5		
6.4.1	Mandatory voltage tripping requirements (OV/UV)	4		
6.4.2	Voltage disturbance ride-through requirements	4		
6.4.2.5	Ride-through of consecutive voltage disturbances	6		
6.4.2.6	Dynamic voltage support	22		
6.5.1	Mandatory frequency tripping requirements (OF/UF)	4		
6.5.2	Frequency disturbance ride-through requirements	4		
6.5.2.5	Rate of change of frequency (ROCOF)	4		
6.5.2.6	Voltage phase angle changes ride-through	6		
6.5.2.7	Frequency-droop (frequency-power) capability	7		
6.5.2.8	Inertial response	22		
7.2.2	Power Quality, Rapid voltage change (RVC)	7		
7.2.3	Power Quality, Flicker	7		
7.3	Limitation of current distortion	7		
7.4	Limitation of overvoltage contribution	7		
8.1	Unintentional islanding	8		
8.2	Intentional islanding	8		
9	Secondary network	32		
10.1	Interoperability requirements	9		
10.2	Monitoring, control, and information exchange requirements	9		
10.3	Nameplate Information	9		
10.4	Configuration information	9		
10.5	Monitoring information	10		
10.6	Management information	10		
10.7	Communication protocol requirements	10		
10.8	Communication performance requirements	10		
10.9	Cyber security requirements	10		
11	Test and verification	11		
11.4	Fault current characterization	5		